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Army Technology Development

IBIS Query

Software to Support the Image Based Information System (IBIS) Expansion for Mapping, Charting, and Geodesy

Prepared for
U.S. ARMY CORPS OF ENGINEERS
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The Image Based Information System (IBIS) has been under development at the Jet Propulsion Laboratory (JPL) since 1975. It is a collection of more than 90 programs that enable processing of image, graphical, and tabular data for spatial analysis. IBIS can be utilized to create comprehensive geographic data bases. From these data, an analyst can study various attributes describing characteristics of a given study area. Even complex combinations of disparate data types can be synthesized to obtain a new perspective on spatial phenomena.

In 1984, new query software was developed enabling direct Boolean queries of IBIS data bases through the submission of easily understood expressions. An improved syntax methodology, a data dictionary, and display software simplified the analysts' tasks associated with building, executing, and subsequently displaying the results of a query. The primary purpose of this report is to describe the features and capabilities of the new query software. A ...

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Information Sciences Division
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SECTION 1

INTRODUCTION

The Image Based Information System (IBIS) has been under development at the Jet Propulsion Laboratory (JPL) since 1975. It is a collection of more than 90 programs that enable processing of image, graphical, and tabular data for spatial analysis. IBIS can be utilized to create comprehensive geographic data bases. From these data, an analyst can study various attributes describing characteristics of a given study area. Even complex combinations of disparate data types can be synthesized to obtain a new perspective on spatial phenomena.

In 1981, a methodology was developed for using IBIS to construct data bases that could be subsequently queried through direct submission of Boolean expressions (Friedman, 1982). The process of building a data base that could be queried was not complicated; and no new IBIS software had to be developed. However, the process of creating Boolean statements and executing queries was not simple. The query software, although functional, was not very sophisticated or user-friendly. The analyst was required to remember the entire complex structure of the data base in order to build any query. This requirement usually resulted in the production of detailed lists that mapped out the complex relationships between the various data objects contained in the data base. Despite this drawback, the query software proved to be an effective tool for spatial analysis. As a result of these developments, a new endeavor was begun to develop more sophisticated and user-friendly query software.

In 1984, new query software was developed enabling direct Boolean queries of IBIS data bases through the submission of easily understood expressions. An improved syntax methodology, a data dictionary, and display software simplified the analysts tasks associated with building, executing, and subsequently displaying the results of a query. The primary purpose of this report is to describe the features and capabilities of the new query software. A secondary purpose of this report is to compare this new query software to the query software developed previously (Friedman, 1982). With respect to this topic, the relative merits and drawbacks of both approaches are covered.

1.1 BACKGROUND

IBIS has been developed out of the need to merge digital imagery data, such as that obtained from airborne and satellite scanners, with the more traditional geographic data such as thematic maps and tables. Due to differences in methodology for automated storage of these disparate data types, the imagery and geographical data cannot be directly used in computerized integrated analysis. With IBIS, however, these data types can be transformed into a standardized group of data formats that can be easily interfaced for spatial analysis.

The primary data storage medium for IBIS is the data plane, or digital image (raster); however, vector-graphics and tabular data sets are handled as well. In order to compare vector-graphics files with image data, the vector data are first converted into image format. To perform this function, a

complete set of software is provided to enable (1) the initial reformatting of input data from outside sources, (2) the correction of both global and local spatial distortions, and (3) the conversion of vector-graphics formatted data into the raster format. A large number of IBIS programs have also been developed to process data stored in tabular form. These data are stored in files referred to as attribute files (previously referred to in other documents as interface files). The variety of software for processing attribute files is quite diverse, including programs that enable processing of complex mathematical expressions and models as well as basic programs for file maintenance and listing. Depending on the application, these attribute files may be processed independently; but they are most commonly linked to one or more specialized data planes referred to as region-coded data planes. Region-coded data planes are used to represent geographical areas, or regions, in an image context. When used in the latter mode, these attribute files usually provide spatial context to their associated region-coded data plane.

Initial applications with IBIS pertained to merging thematically classified Landsat data with some form of georeference material for the purpose of reporting land cover distributions within commonly understood boundary regions such as census tracts (Angelici and Bryant, 1976; Bryant, 1976). Subsequent advancements in IBIS enabled the construction of large digital image mosaics and data bases with precise planimetric qualities (Zobrist, 1979). Cartographic applications based solely on the digital analysis of thematic maps and other nonimage source materials have also been completed with IBIS. One application dealt with modeling subsurface coal resources in Illinois (Farrell and Wherry, 1978). Another application (Logan, 1981) dealt with the analysis and modeling of the potential for debris slides occurring in mountainous terrain.

Multilayered data bases, containing several independent region-coded data planes and their associated attribute files, were constructed in order to perform the last two referenced IBIS applications. Analysts subsequently developed complex batch-entry computer programs to perform the needed modeling on those data bases. The results of those applications were quite effective, and proved that IBIS could be used to merge disparate cartographic data for modeling applications.

An offshoot of those applications was the realization that IBIS data bases could be constructed to facilitate data base queries by submission of Boolean query expressions. The first application of a query procedure involved the analysis of a vegetation map containing four levels of detail. The map itself was quite complicated, as it depicted four layers of vegetation information on a single map sheet. Human interpretation of the map was nearly impossible. However, once an IBIS data base was constructed, it became quite easy to analyze the map data by submitting Boolean query statements. The data base for that operation was quite simple, containing only one region-coded data plane and its associated attribute file. The capability to query a data base containing a single data plane and attribute file had been proved. That work paved the way towards the development of query software that could be utilized to analyze complex data bases.

1.2 IBIS QUERY DEVELOPMENT

The first IBIS data base query software (Friedman, 1982) involved the execution of a previously stored sequence of batch-entry job steps and operated on a data base derived from four independent map sources. The four source maps were converted into IBIS data sets through previously developed and tested methodology. Then the four region-coded data planes were combined to create a higher level region-coded data plane referred to as a composite feature (CF) data plane. Rather than processing and querying the four independent region-coded data planes, the CF data plane and its associated attribute file was actually queried. The query statements themselves were produced by the analyst at run-time, and consisted of a Boolean expression similar to those used in FORTRAN for logical Boolean operations. This process proved to be quite effective and provided the first capability to query large IBIS data bases.

Although the first batch query procedure was an effective tool, several aspects of that procedure made it unwieldly to utilize. Creating the CF data plane and its associated attribute file was a complicated process. Furthermore, the methodology employed prohibited the addition of new region-coded data planes to the data base without complete reconstruction of the CF data plane. Even after the data base was constructed, the actual development of query statements was complicated by the fact that the user had to remember all aspects of data base organization. Additionally, the syntax for developing query expressions was not considered to be user-friendly. Finally, the query process in itself could be simply improved by making it an interactive process.

1.3 ADVANCED IMAGE QUERY

Some improvements to the batch query procedure were obtained through a simple modification making it a semi-interactive procedure. The actual software involved in query processing was unchanged, but the action of placing the procedure within an interactive context was a significant improvement in itself. However, removal of the obstacles previously described necessitated a complete redevelopment of the query concept. A new query procedure was developed that operated directly on the individual region-coded data planes comprising a data base instead of querying the CF data plane. Part of the improvement was the development of a new query language and the introduction of a data dictionary. Finally, the query software was merged with existing interactive image display software to provide more versatility for the user.

1.4 DEMONSTRATION DATA BASE

A demonstration data base was built to test both the batch and interactive query software. Source materials for the data base consisted of four sets of thematic information on three film transparencies. The four themes

included were: (1) land use (Figure 1-1), (2) elevation (Figure 1-2), (3) 100-year floodplain, and (4) land use revisions (both on Figure 1-3). The source maps were digitized, producing four IBIS vector-graphics files. Vector-graphics files are used to store coordinate data within IBIS. Those files were subsequently processed in order to create four IBIS region-coded data planes and four attendant attribute files. Additional processing steps were also required to prepare the data base for the batch query procedure in order to develop the CF data plane.

1.5 APPROACH

In order to provide perspective on the differences between this new approach and the earlier IBIS effort, both the original and the new query processes are described. The original query procedure is covered in Section 3, and the new method is described in Section 4. Preceding those two sections, a brief description of the test data base, including the method of its construction, is covered. A more detailed description of the development of the test data base can be found in Section 2 of Image Based Approach to Mapping, Charting, and Geodesy (Friedman, 1982). Finally, several sample query results can be found in Appendix A, and a detailed listing of the contents of the data base can be found in Appendix B.

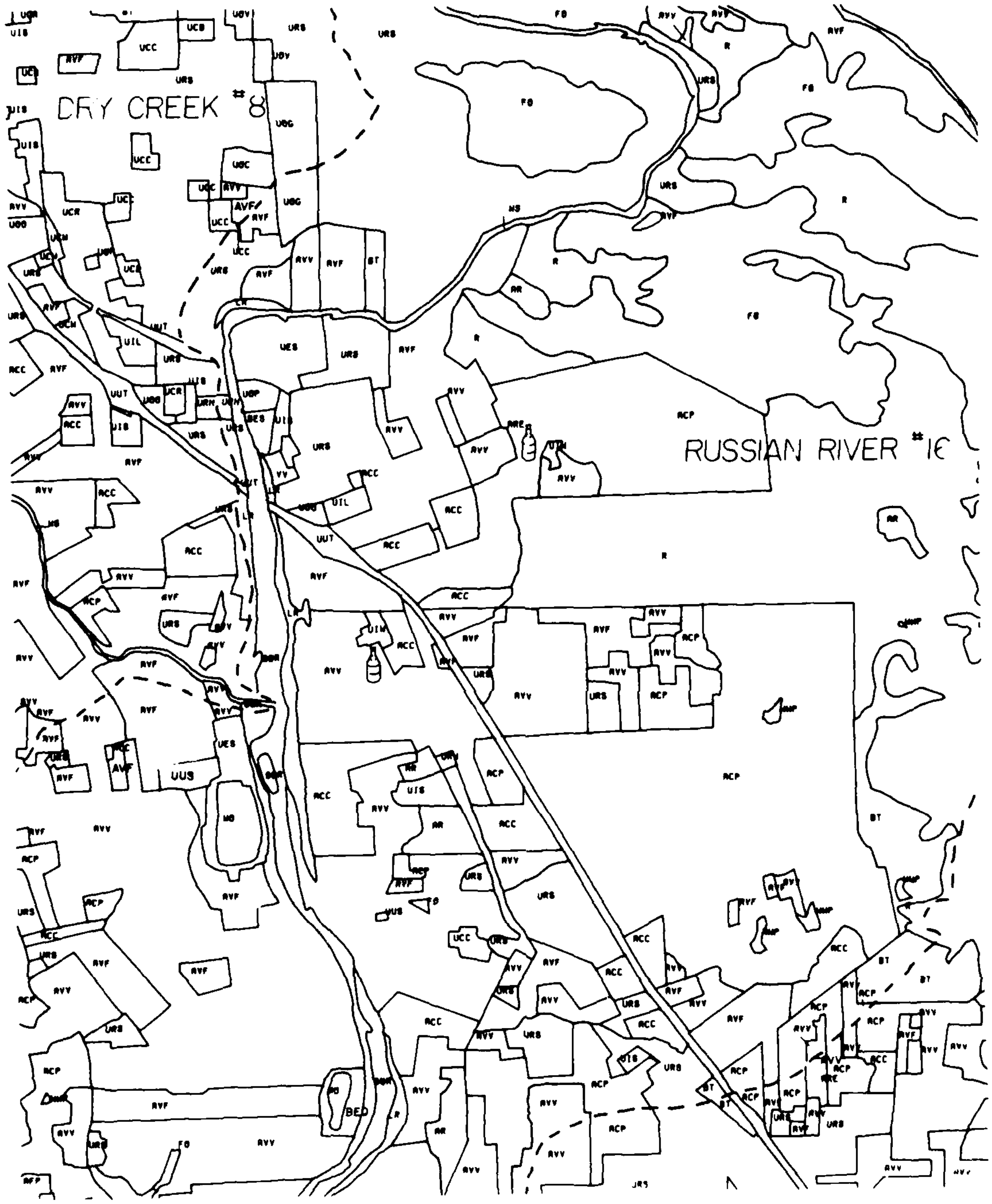

Figure 1-1. Land Use Base Map Used in the MC&G Application

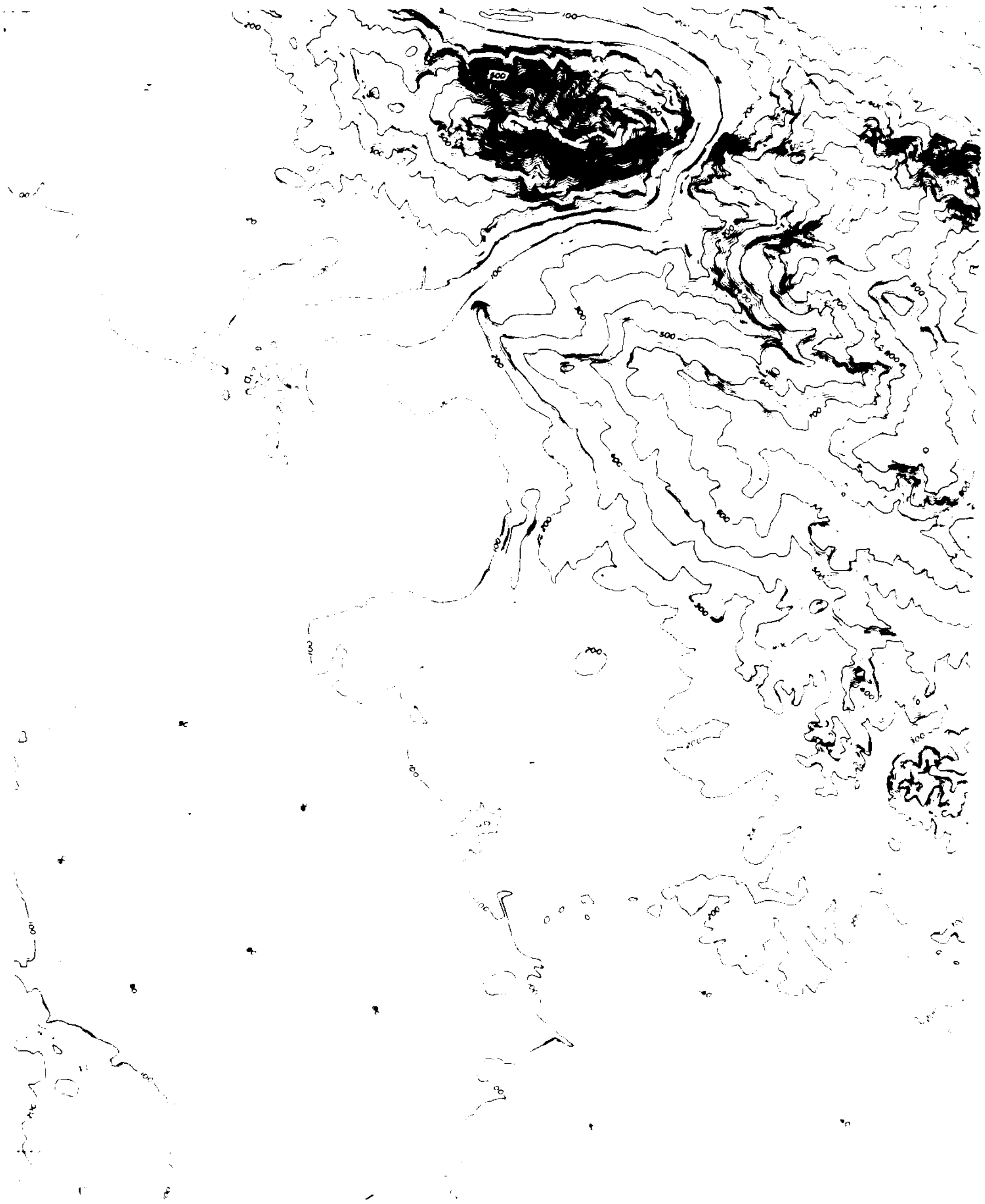

Figure 1-2. Topographic Base Map Used in the MC&G Application

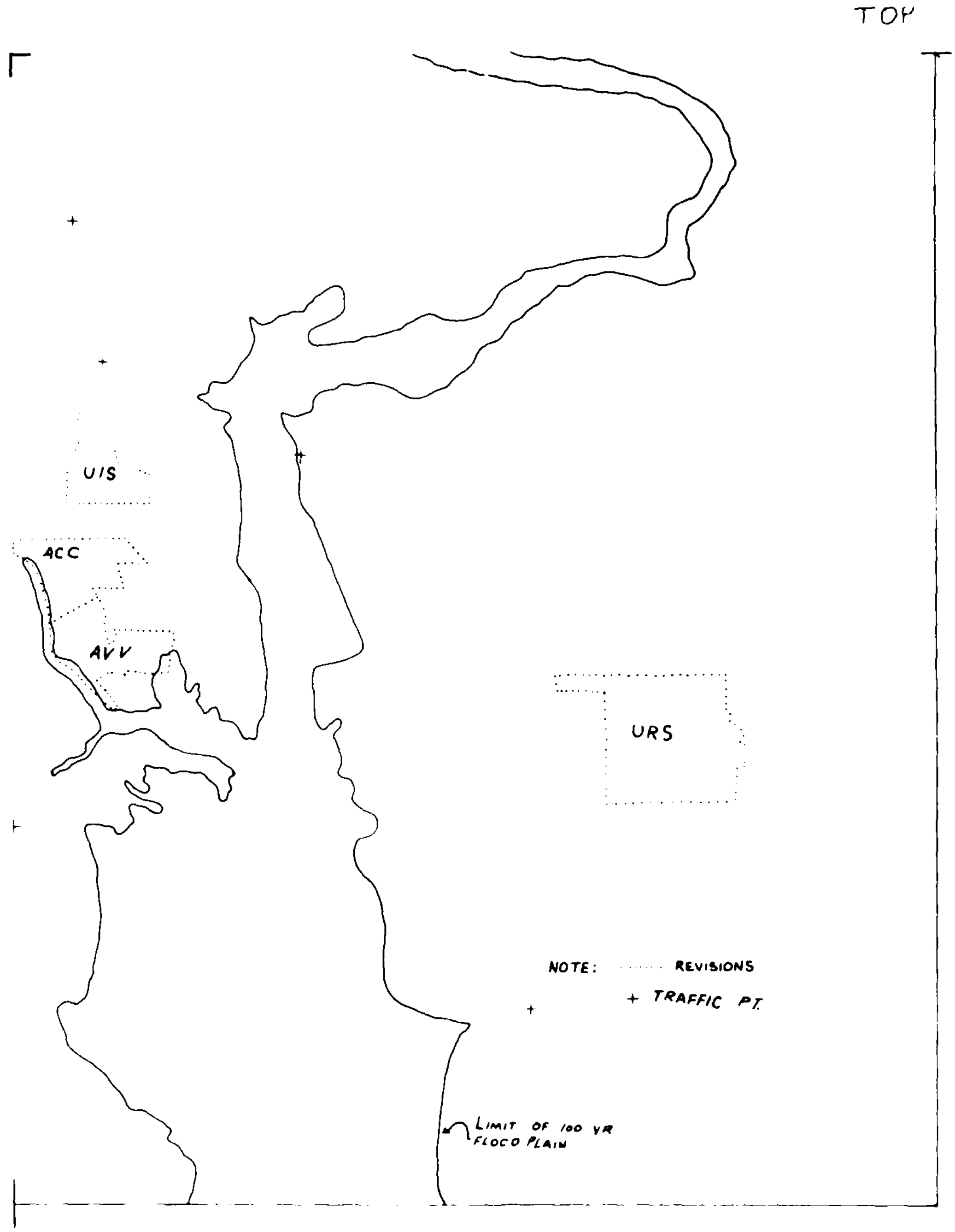

Figure 1-3. Two Themes, the 100-year Floodplain and Land Use Revisions, Provided on the Same Base Map for MC&G

SECTION 2

DEVELOPMENT OF THE DEMONSTRATION DATA BASE

An IBIS data base was constructed for the purpose of demonstrating the query software. The data base represented aspects of the physical and cultural environments in and around Healdsburg, a small city in the wine country of northern California. Source materials used in the construction of the data base were three film transparencies containing four categories of thematic information: (1) land use, (2) zones of elevation, (3) the 100-year flood-plain, and (4) land use revisions. The film transparencies were originally hand-drawn and registered to the Healdsburg topographic map (1:24,000 scale) produced by the US Geological Survey. The source data cover about 14.5 square miles of the northeast corner of that quadrangle.

The query data base itself includes four IBIS paired-data sets (PDS). Each IBIS PDS is composed of two files, a region-coded data plane and its subordinate attribute file. The region-coded data plane embodies the spatial component of a PDS. Within that data plane, individual regions are uniquely identified by assigning all pixels within each region a unique gray tone (DN value, an eight-bit binary value). Each attribute file is subordinate to a region-coded data plane and contains specific tabular information describing attributes of the regions in the associated region-coded data plane. Several categories of information, such as each region's DN code, attribute label, and areal coverage, are possible attributes that can be stored in an attribute file. The logical association between each region-coded data plane and its associated attribute file is derived from the fact that region codes are represented in both data sets, either as a DN value in the case of the region-coded data plane or as an attribute representing a DN code in the case of the attribute file. Since region codes are represented in both companion files, data can be freely exchanged between them. For example, attribute data can be mapped onto a region-coded data plane (Friedman, 1980), or pixel counts can be tabulated by region and entered into an attribute file (Angelici and Bryant, 1976).

2.1 PREPROCESSING

The creation of the Healdsburg data base involved the execution of a series of preprocessing steps. In this context, preprocessing refers to all procedures necessary for the preparation of the data base, but it does not include any processing directly associated with data base queries. When raw data are made available in the form of map transparencies, as was the case in this application, preprocessing can be divided into six distinct phases: (1) coordinate digitization, (2) reformatting, (3) spatial rectification, (4) vector-to-image conversion, (5) region coding, and (6) region labeling. The end result of completing these processing steps is the creation of an IBIS PDS composed of one region-coded data plane and one attribute file. Several of

these data sets were created in building the Healdsburg data base. Data processing steps listed above are briefly described in the following portion of this report.*

2.1.1 Coordinate Digitization

When source data are provided in the form of thematic maps or other two-dimensional hard copy, the data must undergo several processing steps before they can be used for IBIS query operations. The first step in this process is to convert map data into an electronic, computer-readable form. This process, referred to as digitizing, basically involves tracing map features with an electronic device that records their coordinate positions.

Coordinate digitization of the Healdsburg data base involved the production of two separate files for each of the four thematic overlays. First, line segments were traced to define the boundaries between geographic regions. A series of Cartesian coordinates (x,y) were recorded to represent each line segment. A separate line segment file was prepared for each map. Then, a second set of files containing region attribute (label) and positional reference information was digitized. One label was recorded for each region followed by a digitized coordinate that provides the physical mapping of the label to a specific region. These data provide the spatial component for the data base, eventually becoming region-coded data planes. These data provide the basis for the development of attribute files. Check plots were prepared to verify the quality of the digitization and to determine where corrections were required. Several iterations of preparing test plots and subsequent editing of the digitized files were completed before error-free products were produced (Figures 2-1, 2-2, and 2-3).

2.1.2 Reformatting

The final products obtained from the digitizing effort were eight files recorded on magnetic tape--four files containing boundary information and four files containing attribute data. Before those files could be used in IBIS query applications, they had to be reformatted to conform to the Video Image Communication and Retrieval (VICAR) system, and hence IBIS, standards for data set configuration. Two modifications were made on all input digitizer files. First, various system labels that describe data set attributes to VICAR (and IBIS) programs were added to each file. Then, the internal data format of the coordinate data was modified to conform to IBIS vector-graphics file specifications. Basically, all this step involved was the simple conversion of the data from the integer storage format of the digitizer to the real-data storage format used within IBIS. After these two steps were completed, the data sets were ready for the next data processing phase, spatial rectification.

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*A more detailed description of the steps for data base preparation can be found in Image Based Approach to Mapping, Charting, and Geodesy (Friedman, 1982). An overview of IBIS, including a detailed description of the relationship between region-coded data planes and attribute files, is covered there.

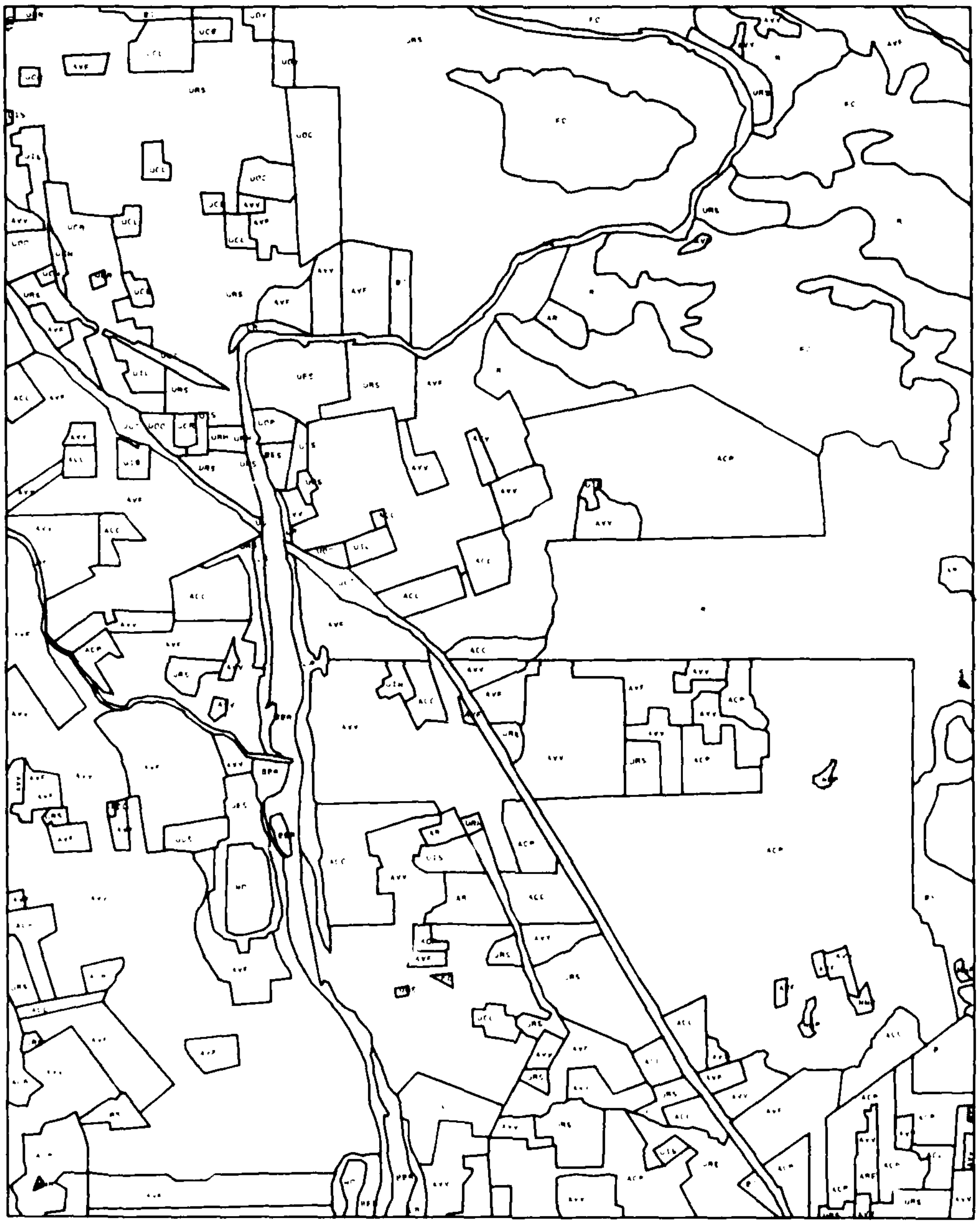

Figure 2-1. Check Plot of Land Use Overlay as Digitized by the Vendor

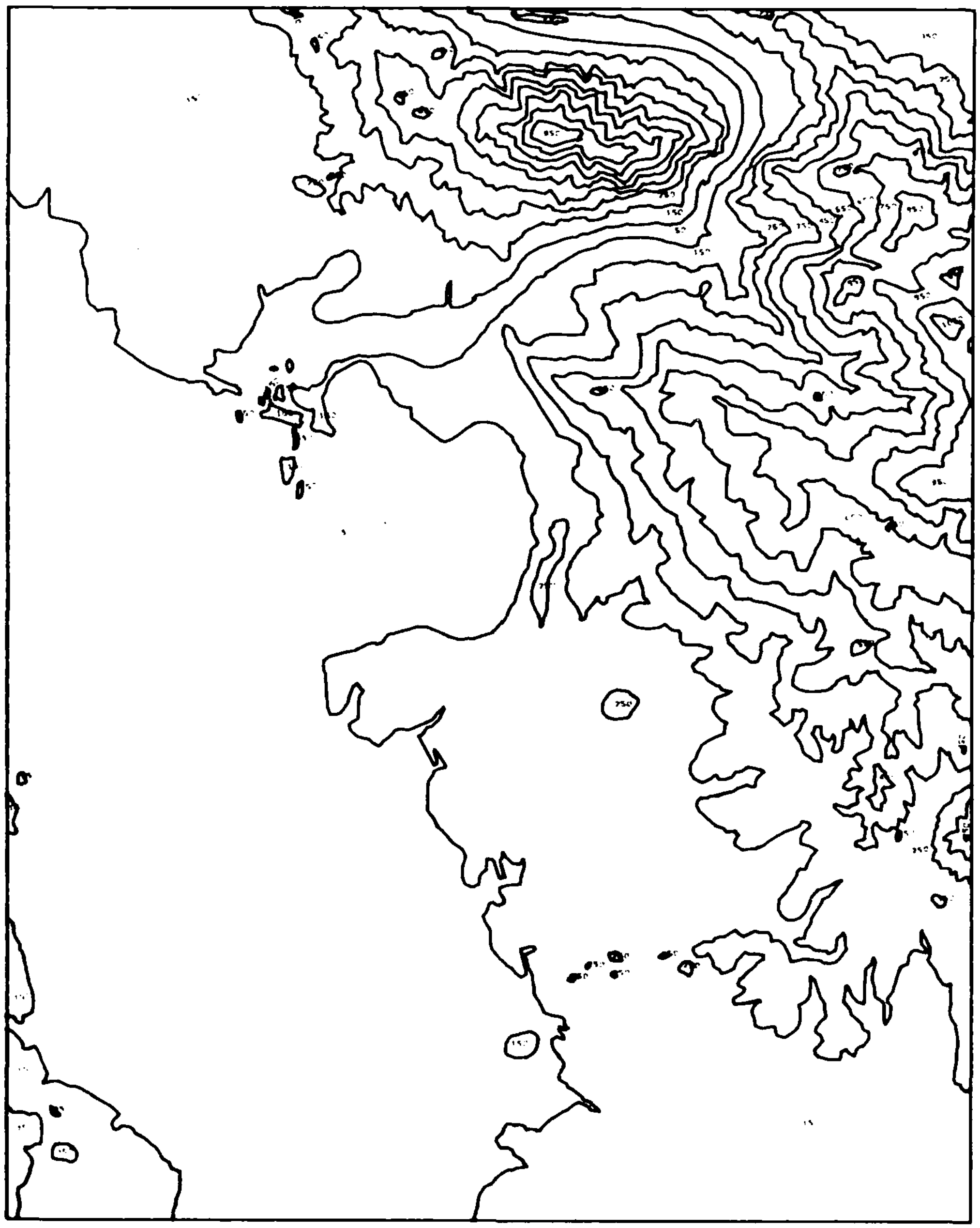

Figure 2-2. Check Plot of Contour Overlay as Produced by the Vendor

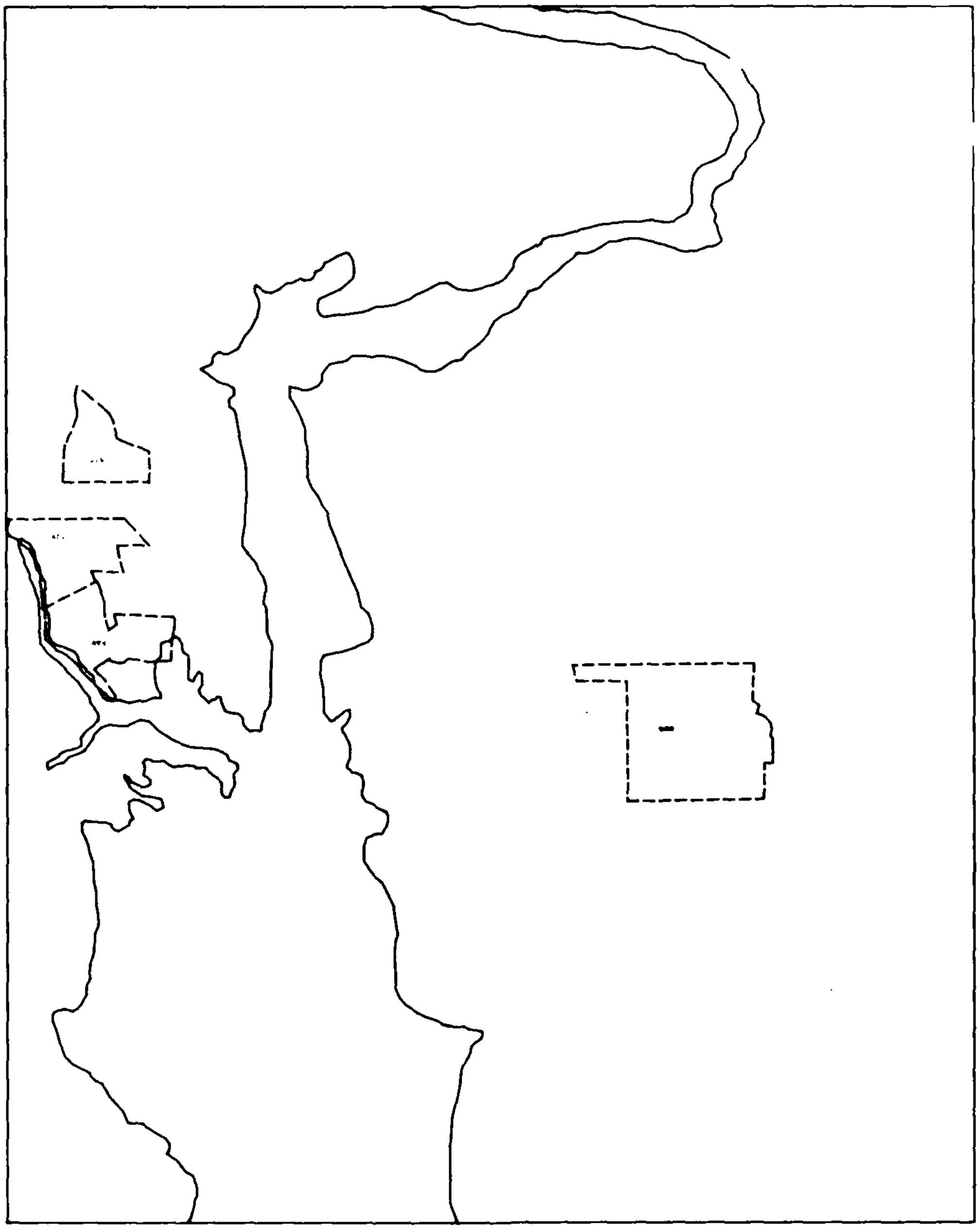

Figure 2-3. Check Plot of Floodplain and Land Use Revision Overlays as Produced by the Vendor

2.1.3 Spatial Rectification

When a geographic data base is being constructed for query, spatial continuity between all layers of the data base is essential. Misregistration or improper spatial alignment between the region-coded data planes would cause misrepresentation of the test area when the data base is queried. In order to maintain registration, all data planes are registered to a planimetric base known to have good spatial continuity. This process serves two purposes. First, data that were originally digitized from maps of differing scales and possibly different origins can all be referenced to the same absolute scale of the planimetric base. Second, local registration anomalies frequently occur as a result of map projection, digitizer operator error, or interpretation. Frequently, they can be easily corrected through invoking IBIS spatial rectification software.

Usually, two types of spatial transformations, affine and piecewise geometric, are employed to bring data into proper alignment with the planimetric base. Two IBIS programs, POLYREG and POLYGEOM, provide these capabilities. POLYREG, an affine transformation program, is first employed to obtain a close spatial fit to the planimetric base. A test lot or test image (Section 2.1.4 describes that process) is usually produced to verify the closeness of fit. Then small local aberrations in alignment are identified and tiepoints are selected to define local deformation patterns. These tiepoints are input to POLYGEOM, a piecewise processing program, for finer adjustments or corrections. Again, test plots or images are produced to check for registration accuracy. Usually, several iterations of adjusting registration tiepoints and running POLYGEOM are required when a precise fit is needed. However, when only close spatial alignment is needed, use of POLYREG alone produces acceptable results.

All source materials used for the Healdsburg data base were obtained directly from a US Geological Survey topographic map and from overlays that were registered to that topographic map. Since the polyconic projection used for the Healdsburg quadrangle is an acceptable source of spatial continuity for small geographic regions such as the Healdsburg area, the topographic map itself was selected to be the planimetric base.* All but one of the data files were transformed to the coordinate reference of the planimetric base by using POLYREG alone, as the simple two-dimensional affine transformation (scale, offset, and rotation) proved to be sufficient for registration among the images. Additional, minor local-area adjustments were required to bring the land use revision map into spatial alignment. The IBIS program POLYGEOM was utilized for that purpose.

*The actual topographic map was never converted to image form. However, the geometry as defined by the topographic map was used to provide the planimetric base for the data base. The relative scale of the image data base was set at 1:240,000. At that scale one pixel represents 400 square feet and is 20 feet on a side.

2.1.4 Vector to Image Conversion

The IBIS data plane, or raster image, is the primary data structure for much IBIS processing. Once the digitized map data are converted into the IBIS vector-graphics format and are transformed to register with the planimetric base, the next processing step is the transformation of the vector data into data planes using the IBIS program <u>POLYSCRB</u>. The operation of POLYSCRB is analogous to the way in which a plotter converts vector data into a hard-copy plot, with the exception that the output medium is a digital image instead of a piece of paper. The program reads IBIS vector-graphics data one line at a time, scribing each line onto the raster image. For each line segment processed, a one-pixel-wide line joins all vertices defining that line. When the process is completed, a data plane containing a scribed representation of all line segments as defined by the input vector-graphics data file is obtained.

Each of the four independent vector-graphics files was processed, yielding four data planes representing the four basic themes. An additional data plane was created by combining those four data planes into one image. This data plane contained the composite boundary information contained in the four data planes previously developed (Figure 2-4). It has a special functionality, the topic of which will be described in Section 2.3.1.

2.1.5 Region Coding

Region-coded data planes are one of the two end products of preprocessing that are directly usable in query operations. These data planes are used to represent the spatial component of the data. The region-coded data plane is a uniquely designed data plane because pixel DN values are used to distinguish regions from each other. In contrast, data planes produced by program POLYSCRB contain region boundary information where the boundaries of the regions are represented by DN code but are not distinguishable from each other. This process of converting the data planes created by POLYSCRB into region-coded data planes that can be used for data base queries is referred to as <u>region coding</u> and is accomplished through IBIS program <u>PAINT</u>. Although the specific details of the operation are complex, PAINT basically processes an input image line-by-line, pixel-by-pixel. The first pixel of an image is assigned an initial DN value. All subsequent pixels along the line are assigned the same DN value until a boundary pixel is encountered. When such a condition arises, the DN value is incremented by a value of one, and the next group of pixels are assigned that DN value until the next boundary pixel is processed. The process continues until the entire line is processed in that manner. For subsequent lines, the same process of pixel assignment is repeated, with the additional construct that the previous line is used to seed the DN value for all regions that are continued from it.

The four data planes representing the original thematic overlays produced by program POLYSCRB and the combined boundary data plane produced by combining the four overlays were input individually to program PAINT for region coding.

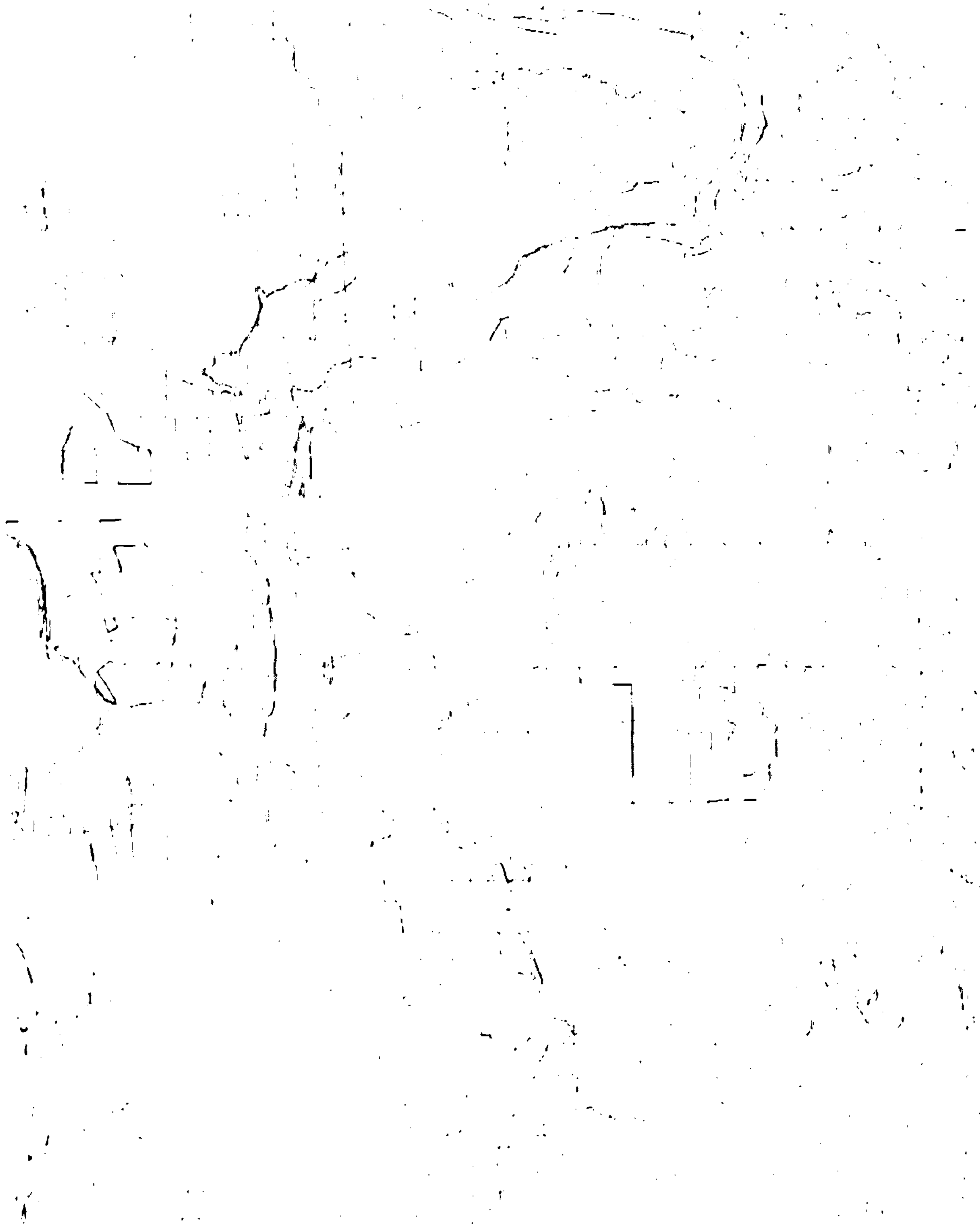

Figure 2-4. Composite Feature Data Plane Prepared by Combining the Four Thematic Data Planes

The result of that process was the creation of five region-coded data planes (Figure 2-5 shows one example). The number of unique geographic regions comprising each region-coded data plane was reported by IBIS program PAINT (Table 2-1).*

Since visual discrimination of each nominally encoded geographic region is nearly impossible, a four-color mapping program, COLOR, is frequently utilized to enable visualization of the regional morphology (Figures 2-6 and 2-7). The COLOR product is primarily used as an aid in editing operations, its main function being the determination of whether all regions have been properly identified through program PAINT. Frequently, line segment digitizing errors go undetected until this point, where COLOR makes such errors stand out. When such an error is detected, the digitizer files must be corrected and the data must be reprocessed by using POLYREG, POLYGEOM, POLYSCRB, PAINT, and finally COLOR.

2.1.6 Region Labeling

Region-coded images are useful in geographic analysis because they provide the spatial context for studying various phenomena. Because of their coding structure, region-coded images can be used to discriminate between neighboring administrative districts, such as state, county, or municipal regions, as well as for unique identification of land use or land cover polygons. However, these region-coded images do not provide the full context needed for geographic analysis. What is missing are label references describing the specific attributes that provided the basis for the identification of the specific regions in the first place. For example, if a census tract map was digitized, the identification code numbers for each census tract must also be recorded for the region-coded image to be useful in geographic analysis.

In Section 2.1.1 of this document it was stated that two types of information were digitized from each of the four thematic map sheets: (1) line segments, and (2) region attribute labels. Each region attribute label data file contained geographic reference points recorded in Cartesian space via digitization and associated region (polygon) identification labels for all regions contained therein. As with the digitized line segment data, those region attribute label files had to be processed before they could be useful in subsequent query analysis. Those processing steps are described below.

---

*The actual number of regions comprising each data plane slightly exceeded manual tabulation of geographic areas from the source maps; this discrepancy was attributed to artifacts induced by scale reduction and vector-to-raster conversion. The results of these circumstances caused some regions to become pinched. This condition is frequently encountered but presented no major problem for this specific application.

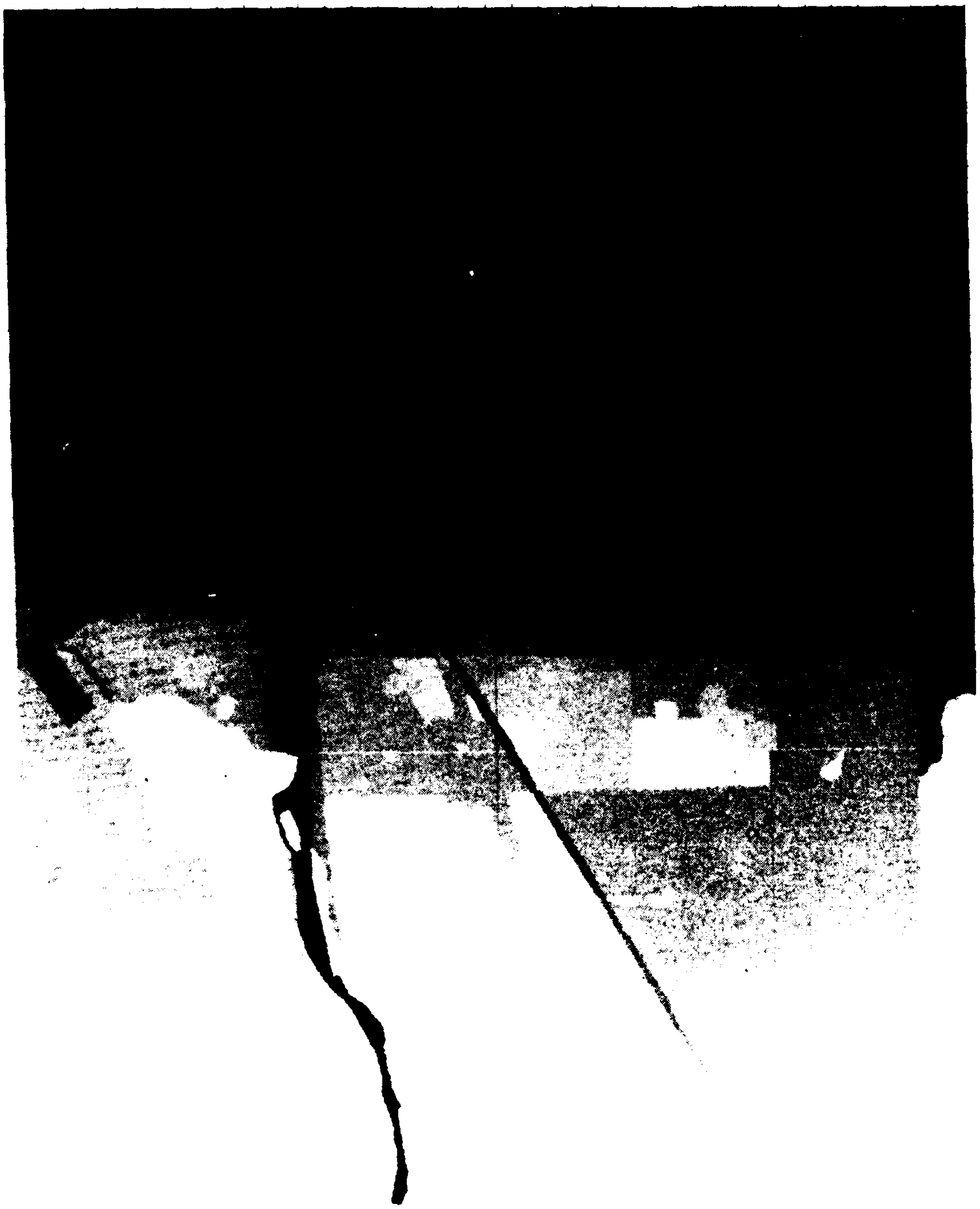

Figure 2-5. Region-Coded Data Plane Representing Land Use. Four other region-coded data planes were prepared for elevation zones, floodplain, land use revisions, and the composite feature data plane.

Figure 2-6. Four-Color Representation of the Land Use Region-Coded *Data Plane*

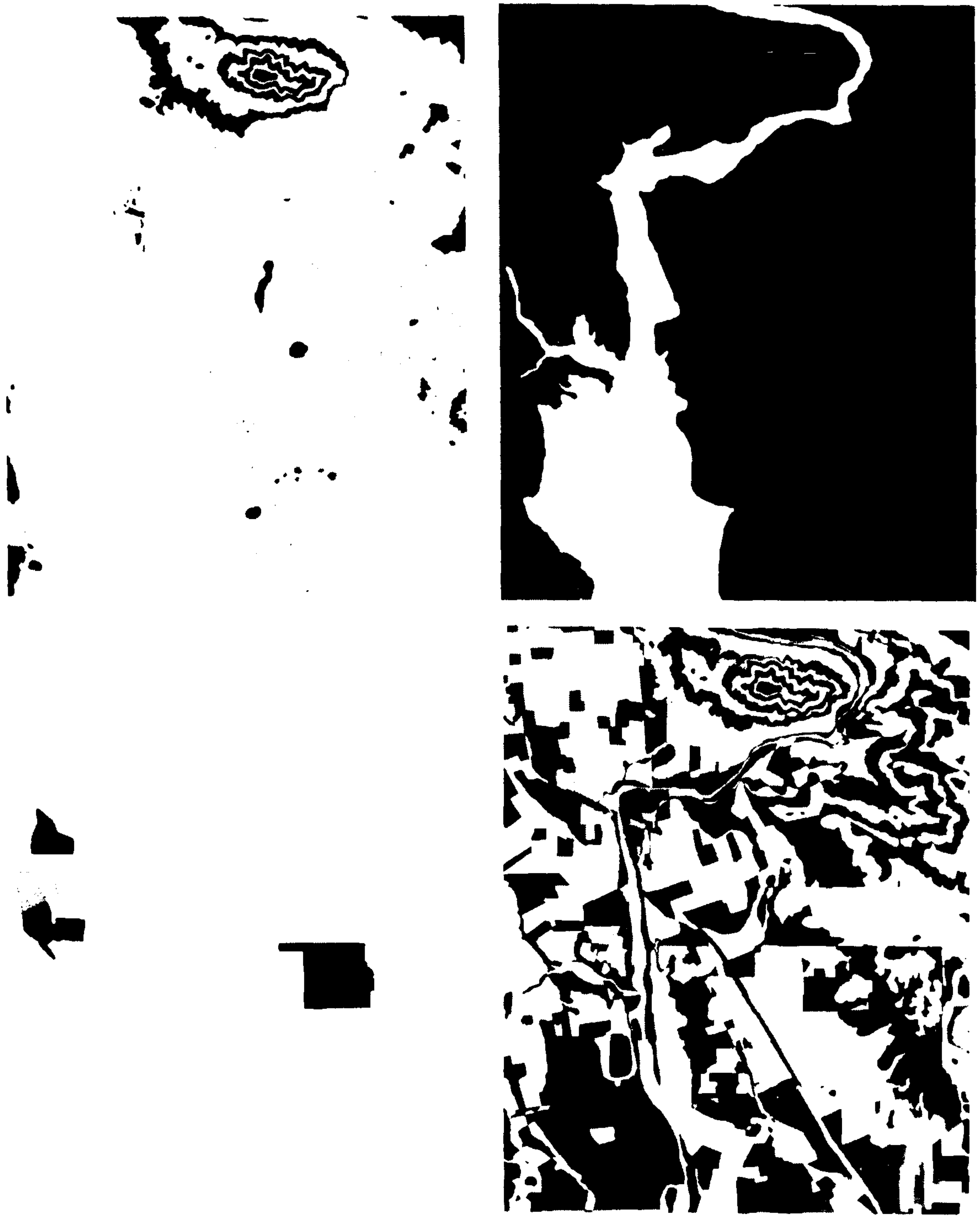

Figure 2-7. Four-Color Representation of the Contour, Floodplain, Land Use Revision, and Composite Feature Data Planes (left to right, top to bottom)

Table 2-1. Number of Regions per Region-Coded Data Plane

Data Plane	Number of Polygons
Land Use	229
100-Foot Contours	77
100-Year Floodplain	4
Land Use Revisions	5

The region attribute data were processed with the same set of procedures used for the line segment files through the first three processing steps: (1) coordinate digitization, (2) reformatting, and (3) spatial rectification. However, these data files were never converted to images. Instead, the data were eventually converted into IBIS attribute files (attribute files are used within IBIS to store attribute and tabular data). An IBIS program, CTRMATCH (center-match), has been developed to produce a link list between each digitized region label and each region code assigned during the region-coding process. CTRMATCH processes each region label sequentially in the following manner: The pixel value within the region-coded image defined by a label's reference coordinate is read to determine the region code (DN value) assigned to that region. (Since all pixels within a region are coded with the same unique value, that reference pixel is always representative of the value assigned to all pixels in that region.) After the region code is identified, both the region label from the region label attribute file and the region code obtained by CTRMATCH are recorded in the IBIS attribute file.

The previous paragraph describes a complicated subject. To illustrate the process of matching region labels and region codes, the following example is provided. Suppose a region label for a land use polygon coded "ACC" had a reference coordinate after spatial rectification of line 92, sample 57. The CTRMATCH program would read the pixel value at that position within the region-coded image and determine that the region code for that region was 117, thereby establishing a link between the attribute label ACC and the region coded 117. Now that the link is identified, the region label and region code are recorded in two columns of an attribute file, completing the process. Then, the next region label is processed to obtain the linking information for that region. That linking information is also stored in the attribute file. Eventually, all region labels are processed, yielding an attribute file where two columns describe the region label and region code for each region contained in the region-coded data plane.

Four such attribute files were produced for the Healdsburg data base. The land use revision region-coded data have the fewest number of members.

The associated attribute file is extremely simple, having just four entries, and can be used to illustrate the structure of all the Healdsburg data base attribute files (Table 2-2).

When the attribute files were combined with their associated region-coded data planes, four IBIS PDS were formed. Complete geographic identification, both spatial and topical, was achieved.

2.2 IMAGE PLANE OVERLAY AND AREA CALCULATION

Image plane overlay (frequently referred to as polygon overlay in vector-based mapping systems) is a process that enables the computation of the frequency of occurrence of pixel codes representing specific thematic features in one image within the context of recognized regions (e.g., census tracts) defined by a region-coded image. (The IBIS program POLYOVLY is used for image plane overlay.) The most frequent application of image plane overlay is for the computation of the frequency distribution of land cover features identified through multispectral classification of Landsat imagery within geographic regions such as census tracts. The image plane overlay program can also be used to obtain a simple frequency distribution (pixel counts per DN code) of the regions comprising a region-coded data plane. From that information, areal computations can be made. This latter mode of operation was utilized for the query effort.

Typically, the results of image plane overlay are added to preexisting attribute files. In the case of building the Healdsburg data base, frequency distributions derived from image plane overlay were added to the attribute files produced from program CTRMATCH. Once the number of pixels comprising each region was known, a simple mathematical calculation (IBIS program MF, for mathematical formula) could yield areal coverage in any measurement system. Acres and square miles were computed for all regions within each region-coded data plane of the Healdsburg data base. At this point in processing, each attribute file (Appendix B, Tables B-4 through B-7) contained five columns of information: (1) region code, (2) region label, (3) pixel count, (4) areal coverage in acres, and (5) areal coverage in square miles. The land use revision attribute file is reproduced here (Table 2-3) to demonstrate the structure of all the Healdsburg data base attribute files.

Table 2-2. Interface File Representing Land Use Revisions

Region Code	Region Label	
1	(blank)	(non-change areas)
2	UIS	
3	ACC	
4	AVV	
5	URS	

Table 2-3. Final Attribute File for Land Use Revisions

Region Code	Region Label	Areal Coverage Pixels	Areal Coverage Acres	Areal Coverage Sq Miles
1		975334	8995.5	13.99
2	UIS	4390	40.3	0.06
3	ACC	5606	1.5	0.08
4	AVV	6200	56.9	0.09
5	URS	16470	151.2	0.24

2.3 SPECIAL PROCESSING REQUIRED TO SUPPORT THE INITIAL QUERY PROCEDURE

The first IBIS query procedure required some additional data processing to prepare the data sets for query. As previously mentioned, although these processing steps were required, they were not advantageous when considering the long-term use of the data base. Consequently, the elimination of this processing requirement was a major design goal with the new query software.

2.3.1 Development of a Composite Feature Data Plane

The initial IBIS query procedure developed by JPL could be used to query only one region-coded data plane and its associated attribute file. Since the Healdsburg data base was comprised of four data planes, a method had to be devised to enable a single query to operate simultaneously on any or all of the data planes comprising the data base. To do this, the development of a composite feature (CF) data plane was devised. The CF data plane's function is similar in concept to the use of least common geographic units (LCGU) in ODYSSEY (Sharpley et al., 1978, pp. 3-4) and other vector-based mapping systems. The CF data plane would contain all the spatial attributes of the four region-coded data planes previously developed.

The CF data plane was created by first combining the four POLYSCRB data planes (refer to Figure 2-4) representing the four themes and then region-coding that composite image as described in Sections 2.1.4 and 2.1.5 of this report. A total of 764 regions were identified by PAINT and represent the total number of unique region combinations for the four input data planes. The four-color mapping algorithm was implemented to depict the complexity of that image (refer to Figure 2-7).

An attribute file was produced for the CF data plane. As with the other attribute files associated with a region-coded data plane, it contained a column for region code references. However, it did not include physical label references for each region, since labels were never digitized for features formed in the composite image. However, a linkage between the CF attribute file and the other attribute files was necessary if a query was to be performed on the CF data plane. The following method was used to create the attribute

file for the CF data plane. Instead of developing region labels and region code associations through program CTRMATCH, a more complex process was initiated. First, a multi-image plane overlay program (MULTOVLY) enabled the simultaneous overlay of the CF data plane and the four region-coded data planes comprising the data base. (The operation of MULTOVLY is similar to the operation of POLYOVLY, described previously.) The product of that operation was an attribute file containing six columns of descriptive information about region codes for each region underlying a CF region (Table 2-4). This CF attribute file enabled contextual references to be made between the CF data plane and any of the four attribute files representing the four region-coded data planes in the data base.

Since the CF data plane was derived through the combination of the four thematic data planes, the resultant CF attribute file was simply structured (Table 2-5). For example, the characteristics recorded for CF region 25 are associated region codes 13, 11, 4, and 1 for the land use, elevation, floodplain, and land use revision region-coded data planes, respectively. The number of pixels comprising that CF region totaled 1302. All other regions comprising the CF attribute file (Appendix B, Table B-8) can be interpreted in a similar manner.

2.3.2 Development of the Master Attribute File

After processing by MULTOVLY, sufficient information is not available to determine the actual composition of a CF region. Without the addition of identifiable attribute labels for the four subordinate region-coded data planes, the CF data plane and attribute file would be of little utility for query or geographic analysis. However, with the addition of attribute label information from the attribute files associated with the four region-coded data planes, the CF attribute file can contain sufficient information to facilitate analysis and query. The IBIS program MERGE was used to combine the attribute features of the subordinate attribute files with the CF attribute file. The end result of the process was the development of a master attribute file (MA file). (Again, the development of this file was necessary only for the initial query procedure and was not used after the new query software was developed.) After the attribute codes were added to the MA file, areal calculations for all CF regions were completed as done before for the four other attribute files using IBIS program MF.

Table 2-4. Structure of the CF Attribute File

Column	Contents
1	Region Codes for the CF Data Plane
2	Region Codes for the Land Use Region-Coded Data Plane
3	Region Codes for the Elevation Zones Region-Coded Data Plane
4	Region Codes for the 100-Year Floodplain Region-Coded Data Plane
5	Region Codes for the Land Use Revision Region-Coded Data Plane
6	Pixel Counts for the CF Data Plane

Table 2-5. Partial Listing of the CF Attribute File

Column:	(1)	(2)	(3)	(4)	(5)	(6)	
Contents:	CF	Land Use	Contour	Flood	Revision	Pixel	(Pixel
Contents:	Code	Code	Code	Code	Code	Counts	Counts)
	1	1	1	1	1	109	
	2	2	1	1	1	209	
	3	3	1	1	1	52030	
	.	.	.	.	.	...	
	.	.	.	.	.	...	
	.	.	.	.	.	...	
	25	13	11	4	1	1302	
	.	.	.	.	.	...	
	.	.	.	.	.	...	
	.	.	.	.	.	...	
	763	229	73	1	1	359	
	764	229	5	1	1	82	

One final augmentation was performed to enable direct querying of the MA file by the initial query procedure. That operation required the use of numerical attribute labels instead of the character codes originally produced at digitization. Consequently, all character labels were given numerical reference codes for query purposes. That information was also stored in the MA file. (Tables defining the relationship between attribute labels and numerical equivalents are contained in Appendix B, Tables B-1 through B-3).

The final MA file used to demonstrate the first query procedure contained tabular information describing (1) region codes for the CF data plane as well as the four other data planes, (2) pixel counts, (3) areal calculations, and (4) character and associated numerical attribute labels. When combined, the attribute file contained twenty columns of information (Table 2-6).

2.3.3 Generation of Tabulations from the MA File

The MA file contains much descriptive information about the Healdsburg area. That information can be formatted and listed in tabular form through the use of the IBIS software programs AGGRG, AGGRG2, COPYFILE, MERGE, TRANSCOL, MF, and REPORT. The specific IBIS procedures involved are not described in this document, as they are adequately explained in other reports (Friedman, 1980; Angelici and Bryant, 1976). However, a brief description of the basic IBIS reporting capability is important to gain perspective on the improvements brought to IBIS with the query software. A very detailed listing of the MA file can be produced, describing the areal coverage for each region in the CF data plane (Table 2-7).

Table 2-6. Composition of the Master Attribute File

Column	Contents	
1	CF Region Code	
2	Number of Pixels per CF Region	
3	-unused-	
4	Land Use	
5	Elevation	Corresponding Region Codes Derived
6	Floodplain	From These Region-Coded Data Planes
7	Revisions	
8	Number of Acres per CF Region (computed value)	
9	Number of Square Miles per CF Region (computed value)	
10	-unused-	
11	Land Use	
12	Elevation	Alphabetic Labels for Region
13	Floodplain	Described in Columns 4-7
14	Revisions	
15	Land Use	
16	Elevation	Numeric Labels for Region
17	Floodplain	Described in Columns 4-7
18	Revisions	
19	-unused-	
20	-reserved for query result-	

Table 2-7. Listing of Several Columns of the Master Attribute File (Partial Listing)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

LAND USE POLYGON CODE	GEOREF REGION CODE	-- AREAL COVERAGE -- PIXELS	ACRES	SQ MILES
1	1	109	1.00	0.00156
2	2	209	1.92	0.00300
3	3	52030	477.78	0.74652
4	4	700	6.43	0.01004
5	5	385	3.54	0.00552
5	6	318	2.92	0.00456
6	7	19199	176.30	0.27547
6	8	64	0.59	0.00092
6	9	13690	125.71	0.19642
6	10	2154	19.78	0.03091
7	11	19591	179.90	0.28109
8	12	1601	14.70	0.02297
8	13	8	0.07	0.00011
8	14	11	0.10	0.00016
8	15	1311	12.04	0.01881
8	16	35	0.32	0.00050
9	17	1992	18.29	0.02858
10	18	401	3.68	0.00575
10	19	8	0.07	0.00011
10	20	124	1.14	0.00178
9	21	39	0.36	0.00056
11	22	476	4.37	0.00683
11	23	3973	36.48	0.05700
12	24	443	4.07	0.00636
13	25	1302	11.96	0.01868
6	26	13	0.12	0.00019
8	27	12	0.11	0.00017
8	28	271	2.49	0.00389
9	29	1203	11.05	0.01726
11	30	73	0.67	0.00105
9	31	616	5.66	0.00884
10	32	366	3.36	0.00525
14	33	2667	24.49	0.03827
15	34	799	7.34	0.01146
6	35	13805	126.77	0.19807
8	36	112	1.03	0.00161
16	37	71	0.65	0.00102
9	38	468	4.30	0.00671
6	39	113	1.04	0.00162
17	40	1180	10.84	0.01693
10	41	53	0.49	0.00076
8	42	38	0.35	0.00055
6	43	464	4.26	0.00666
16	44	162	1.49	0.00232
11	45	313	2.87	0.00449
17	46	85	0.78	0.00122

The process of obtaining a tabular report of areal coverage by a specific topical theme involves some reordering and aggregation of data components within the MA file. For example, utilizing the MA file to generate a report describing land use regions as they are represented in the land use data plane requires merging information from several adjacent CF regions. Since regions within the CF data plane were formed by the intersection of all regions from all input image planes, the attributes of those smaller regions have to be reaggregated within the MA file to represent the original spatial context of the land use data plane before a tabular report can be produced (Table 2-8). This can be accomplished, since attribute information is maintained for all input data planes within the MA file.

Several other themes can be represented through simple manipulation of the MA file. For example, one useful report that can be derived from the MA file is a listing of all unique thematic combinations among the four map base overlays (Table 2-9). Greatly detailed information about the study area as a whole can be gleaned from such a listing. However, little if any information about the spatial distribution of that information is available in this form.

2.4 CONCEPTUALIZATION OF THE HEALDSBURG DATA BASE

With completion of the data base preparation phase, the Healdsburg data base was ready for query. The data base consisted of several representational files derived from the four original thematic data planes (land use, contours, land use revisions, and floodplain) and the newly established CF data plane with its associated MA file. For each of the thematic overlays, a line segment image, a region-coded image, and an attribute file were produced. The relationship between the various data planes and attribute files can be pictorially depicted (Figure 2-8). The only paired data set used for the first query procedure is the composite feature-master attribute PDS, depicted at the center of the diagram. For the later version of IBIS QUERY, the four original themes are used in query operations. Those data sets are depicted as the smaller data sets at the edges of the diagram. In addition to the PDS files, other files registered to the data base, such as the region outline data planes, have been used to provide a spatial context to the results of the query.

Table 2-8. MA File Report Generated by Reporting All CF Components Forming a Land Use Region (Partial Listing)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240.000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY. ENGINEER TOPOGRAPHIC LABORATORIES

POLYGON CODE	POLYGON LABEL	AREAL COVERAGE PIXELS	AREAL COVERAGE ACRES	AREAL COVERAGE SQ MILES
1	UIS	109	1.00	0.00156
		109	1.00	0.00156
2	UCR	209	1.92	0.00300
		209	1.92	0.00300
3	URS	52030	477.78	0.74652
3	URS	156	1.43	0.00224
3	URS	20	0.18	0.00029
3	URS	67	0.62	0.00096
3	URS	9	0.08	0.00013
3	URS	13	0.12	0.00019
3	URS	10	0.09	0.00014
3	URS	757	6.95	0.01086
3	URS	21	0.19	0.00030
3	URS	13	0.12	0.00019
3	URS	64	0.59	0.00092
3	URS	11	0.10	0.00016
3	URS	2081	19.11	0.02986
3	URS	24	0.22	0.00034
3	URS	61	0.56	0.00088
3	URS	38	0.35	0.00055
3	URS	26	0.24	0.00037
3	URS	155	1.42	0.00222
3	URS	35	0.32	0.00050
3	URS	46	0.42	0.00066
3	URS	93	0.85	0.00133
		55730	511.75	0.79961
4	BT	700	6.43	0.01004
		700	6.43	0.01004
5	UOV	385	3.54	0.00552
5	UOV	318	2.92	0.00456
		703	6.46	0.01009
6	URS	14	0.13	0.00020
6	URS	35	0.32	0.00050
6	URS	797	7.32	0.01144
6	URS	56	0.51	0.00080
6	URS	70	0.64	0.00100

Table 2-9. All Unique Data Base Combinations (Partial Listing)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

AGGREGATION BY ALL UNIQUE THEMATIC COMBINATIONS

	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
INDEX	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
1	ACC	50	BELO		9279	85.21	0.13313
2	ACC	50	ABOV		12596	115.67	0.18073
3	ACC	50	ABOV	ACC	1188	10.91	0.01705
4	ACC	50	ABOV	UIS	940	8.63	0.01349
5	ACC	150	ABOV		15027	137.99	0.21561
6	ACP	50	BELO		750	6.89	0.01076
7	ACP	50	BELO	AVV	125	1.15	0.00179
8	ACP	50	ABOV		7538	69.22	0.10815
9	ACP	50	ABOV	AVV	1001	9.19	0.01436
10	ACP	150	ABOV		74268	681.98	1.06559
11	ACP	150	ABOV	URS	1827	16.78	0.02621
12	ACP	250	ABOV		36630	336.36	0.52557
13	ACP	250	ABOV	URS	3328	30.56	0.04775
14	ACP	350	ABOV		12974	119.14	0.18615
15	ACP	450	ABOV		7301	67.04	0.10475
16	ACP	550	ABOV		5545	50.92	0.07956
17	ACP	650	ABOV		6963	63.94	0.09990
18	ACP	750	ABOV		3196	29.35	0.04586
19	AR	50	ABOV		3536	32.47	0.05073
20	AR	150	ABOV		2094	19.23	0.03004
21	AR	250	ABOV		386	3.54	0.00554
22	AR	650	ABOV		840	7.71	0.01205
23	AVF	50	BELO		34024	312.43	0.48817
24	AVF	50	BELO	AVV	261	2.40	0.00374
25	AVF	50	ABOV		61527	564.98	0.88279
26	AVF	50	ABOV	ACC	22	0.20	0.00032
27	AVF	50	ABOV	AVV	2765	25.39	0.03967
28	AVF	50	ABOV	UIS	1918	17.61	0.02752
29	AVF	150	BELO		1332	12.23	0.01911
30	AVF	150	ABOV		34011	312.31	0.48799
31	AVF	150	ABOV	URS	4059	37.27	0.05824
32	AVF	250	ABOV		2566	23.56	0.03682
33	AVF	250	ABOV	URS	249	2.29	0.00357
34	AVF	350	ABOV		573	5.26	0.00822
35	AVV	50	BELO		70181	644.45	1.00695
36	AVV	50	BELO	ACC	25	0.23	0.00036
37	AVV	50	BELO	AVV	117	1.07	0.00168
38	AVV	50	ABOV		48543	445.76	0.69649
39	AVV	50	ABOV	ACC	4309	39.57	0.06183
40	AVV	50	ABOV	AVV	1931	17.73	0.02771
41	AVV	50	ABOV	UIS	526	4.83	0.00755
42	AVV	150	BELO		248	2.28	0.00356
43	AVV	150	ABOV		45201	415.07	0.64854

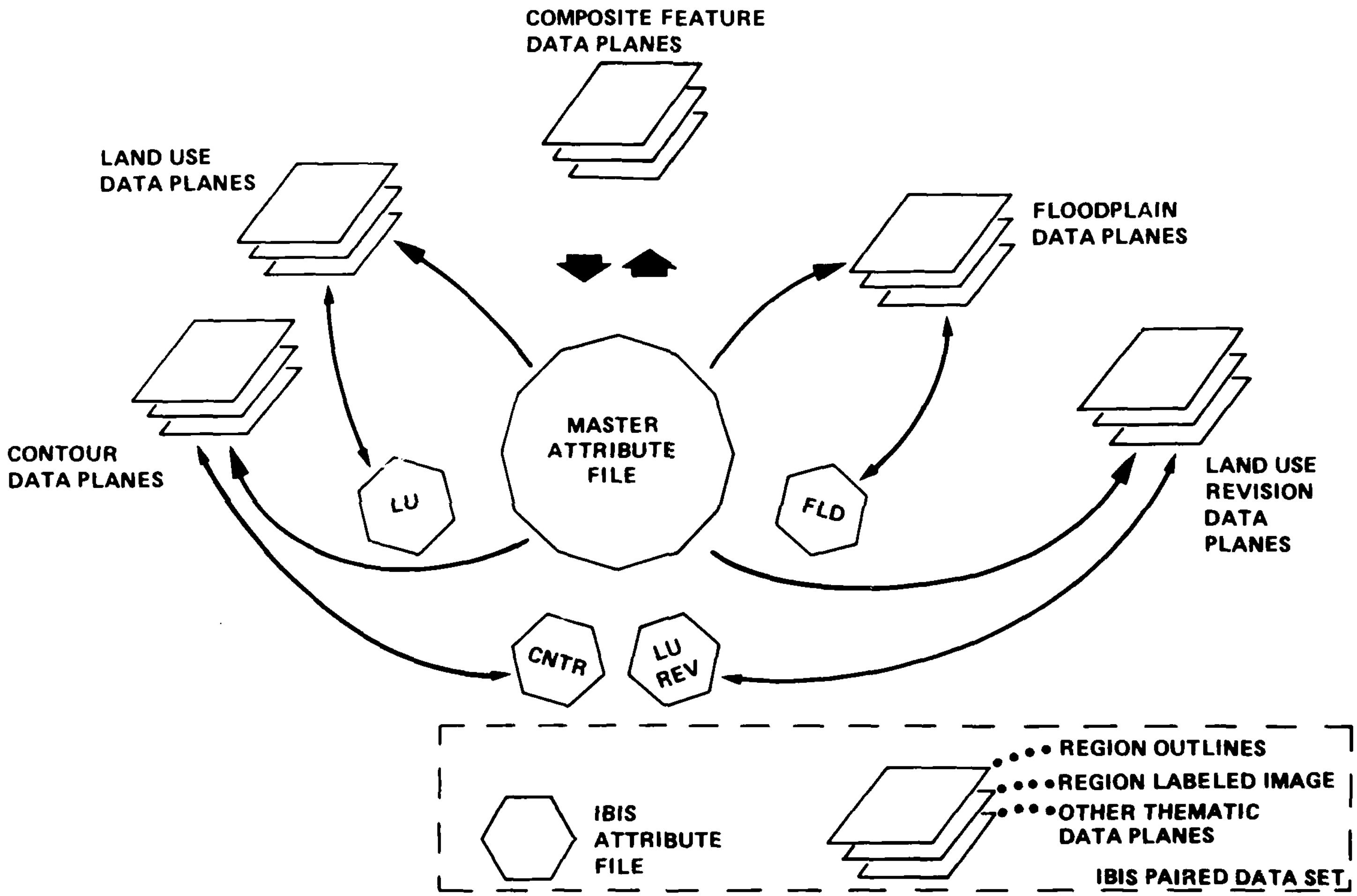

Figure 2-8. Schematic Diagram Depicting the MC&G Data Base (Several sets of image planes and attribute files are all interrelated in the MC&G data base.)

SECTION 3

BATCH-ENTRY QUERY

Through analysis of tabular listings such as those described in the previous section, a great deal of information can be learned about the Healdsburg region. The proportional coverage of specific types of land use or topographic features can be determined. Even the sizes and types of regions that could be subjected to severe flooding during a 100-year flood could be determined with some effort. However, the actual utility of those reports is limited due to the cumbersome nature of the reporting structure and the complexity of the data sets involved. The missing features needed to make such data base information really useful are (1) simple methods to develop queries, and (2) the capability to represent such information in a spatial context. With the reporting procedure previously described in Section 2, there is no way to easily determine what conditions specifically exist, and it is impossible to determine where those features exist within the Healdsburg area.

Two files are used in batch-entry query processing described in this section. The spatial component of the data base is represented by the CF data plane, while attribute data are stored in the MA file. Specific columns of interest to query development are listed in Table 3-1. The complete MA file was described in Section 2 of this document.

3.1 THE IBIS QUERY PROCEDURE

The first query software was developed to address the problems of selection and identification of specific desired themes, leading to their subsequent spatial representation. Since four disparate data sources were integrated in the Healdsburg data base, topical inquiries could be constructed to learn about the nature and distribution of any of those features represented in the data base. Inquiries could be so complex in structure that they could not be easily perceived through traditional map interpretation, and their analysis was made possible only through the query software.

3.1.1 Calling Sequence

The first query software was actually a sequence of batch-entry job steps that were linked to form what is referred to as a procedure. It was developed in the following manner: First, a sequence of IBIS programs were constructed to query the IBIS data base as a batch job. This job sequence was tested and retested until it was determined that the batch job consistently produced accurate results when applied to the data base. Once verified, a parameter processing sequence was placed in front of this job stream, forming a complete query procedure. The procedure was then tested, and once it was determined to operate without error, the query procedure was stored in a run-time program library.

Table 3-1. MA File Columns Used in Query Processing

Column	Contents	Function
1	CF Region Code	Provides context link to CF data plane.
15	Land Use	Codes representing the four themes are stored in columns 15 through 18.
16	Elevation	
17	Floodplain	
18	Revisions	
20	Query Evaluation Result	Results from the query are stored here. If value equals 1, then the query is evaluated true. If zero, then the query is evaluated false.

Once the query procedure as stored in the library, an analyst could simply run a query by calling the procedure with the proper sequence of parameters. The analyst could provide three parameters: (1) the query statement, (2) whether or not a map product was to be produced, and (3) whether or not a special title was to be provided to accompany the map product. Instead of submitting a complex batch job, the stored query procedure was invoked by a call to the query procedure:

```
CALL QUERY,--function--,--special title--,--hard copy--
```

The only parameter required was the query statement itself. The request for production of a hard-copy map product and a descriptive title were optional parameters. Invocation of the query procedure always produced a tabular report describing the results of the query in a format similar to those reports produced for Section 2 of this document.

Restrictions in the formation of procedures dictated by VICAR system design conventions required that each actual query statement be provided within a standard VICAR parameter field. Consequently, the function parameter was only a reference to a VICAR parameter field where the actual query statement was located. In operation, invocation of the query procedure appeared as a series of card images:

```
CALL QUERY,FUN1,DEMONSTRATION OF A QUERY STATEMENT,HARDCOPY
P,FUN1
     --query expression--
```

Several calls to the query procedure could be made within the same job submission. For every query, the same three card image sequence was required.

3.1.2 Query Expression Composition

A query is submitted to learn some fact or facts about the study area. The query expression itself is the vehicle by which a question can be posed to the data base. For example, consider the following question: Which areas are encoded with land use code ACC? It would be nice if an analyst could submit such a simply structured sentence to the query procedure. However, at the time that the first query procedure was being utilized, IBIS query statement interpretation capabilities were not sufficiently developed to enable the interpretation of a question posed in grammatical English or even a pseudo-text language. Instead, the development of the actual IBIS query expression was based on Boolean logic operation syntax supported through IBIS program MF. The most basic query expression was derived from the following statement form:

(COLn {LO} CODE)

where COLn referred to a column in the MA file that contained values representing thematic categories of information. For the Healdsburg MA file, valid values for n were 15 for Land Use, 16 for Elevation Zones, 17 for Floodplain, and 18 for Land Use Revisions. CODE was the actual numeric code used to represent the specific theme to be identified in the expression. Valid values for CODE depended on the specific theme or themes of interest. (They are documented in Appendix B, Tables B-1 through B-3). Finally, {LO} was a logical operator that identified how values in COLn were compared to the value represented by CODE. Valid logical operators were limited to the standard Boolean operators supported in FORTRAN and included .EQ., .LT., .GT., .LE., and .GE.

The logical expression used to identify all land use areas coded ACC was constructed as follows:

(COL15 .EQ. 1)

simply stating that the expression will be evaluated to determine whether values in column 15 representing land use attribute codes in the MA file are equal to 1, the value 1 being a specific numeric attribute code that is identified with the attribute ACC.

3.1.3 Query Expression Evaluation

Once the query statement is interpreted, the MA file is evaluated row-by-row based on the query expression. At each row the actual value stored at COLn is compared to the value represented by CODE. In the example query statement described above, every member in column 15 of the MA file would be checked row-by-row to determine if it equaled the value 1, the numeric code for land use attribute ACC. When the value in column 15 equaled the value 1, the expression was evaluated to be true. Whenever the value in column 15 did not equal 1, the expression was evaluated to be false. The results of the expression evaluation were stored in column 20 of the MA file, which was previously left empty, being reserved for storage of query results. When the query expression was evaluated true, a value 1 was placed in column 20. When the expression was evaluated false, a value of 0 was placed in column 20.

Consequently, after every row was evaluated by the expression, column 20 of the MA file would contain ones and zeros, the value at each row being set depending on whether the expression was evaluated true or false.

Once the expression was evaluated for every row in the MA file, other IBIS programs (not described in this document) were called by the query procedure to develop a tabular report and product map based on the result of the query.

3.1.4 Development of a Complex Query Expression

Complex query expressions could be made by bridging together two or more simple expressions with the logical operators .AND., .OR., and .NOT. to form statement structures such as:

((COLn {LO} CODE) {LO} (COLn {LO} CODE))

Each component of the complex expression was developed based on the description covered in Section 3.1.2. They were evaluated based on standard FORTRAN conventions for evaluation of logical and arithmetic expressions. As with evaluation of the simple expression, the complex logical expression is evaluated row-by-row for the entire MA file; and for each row, the result of the query was placed in column 20 of the MA file.

Complex expressions could be used for many purposes. They could be formulated to identify several attributes within the same column. For example, the expression

((COL15 .EQ. 1) .OR. (COL15 .EQ. 6))

was interpreted to be true if values in column 15 equaled either 1 or 6, the codes for ACC and AVV, respectively. Complex expressions could also be developed to enable evaluation of two or more MA file columns:

((COL15 .EQ. 1) .AND. (COL16 .LT. 1))

In this example, the first expression is interpreted to determine whether values in column 15 equal 1, or Land Use equal to ACC, and the second expression is evaluated to determine whether values in column 16 are less than 1, or Elevation is less than 100 feet. When both expressions are evaluated true, the entire complex expression is evaluated true and a value of 1 is placed in column 20. Whenever either (or both) of the two expressions are evaluated false, the entire complex expression is evaluated false and a value of 0 is placed in column 20 of the MA file.

3.2 EXAMPLE OPERATIONS OF THE QUERY PROCEDURE

The batch query procedure was tested to verify its operation. From the very simple operation to the complex query, the procedure proved to be quite effective in providing desired information.

3.2.1 Evaluation of a Simple Operation

A group of simple queries were tested first. An example of such a query would be: "Which areas contain land use regions coded ACC?" As previously stated, the query procedure required that a query be posed with a specialized syntax. The complete query statement for the query is listed below:

```
CALL QUERY,FUN1,ALL LAND COVER UNITS CODED ACC,MAP
P,FUN1
     '(C15 .EQ. 1)'
```

As described previously, the first line identifies the basic call to the query procedure, followed by the function statement reference FUN1, the user-supplied title ALL LAND COVER UNITS CODED ACC, and a request to produce a hard-copy map MAP. The query expression is contained within a standard VICAR parameter statement. The parameter is identified by the statement P,FUN1, with FUN1 representing the parameter name. The expression (C15 .EQ. 1) is enclosed in single quotes to identify to the VICAR system that the expression is a text string instead of a numeric value. As described in Section 3.1.2, the expression (C15 .EQ. 1) is evaluated to determine whether values in column 15 of the MA file are equal to 1, the numeric code to signify the land use feature known as ACC.

The query statement was evaluated for every row in the MA file, until all regions represented in the MA file were checked to determine whether they contained the land use code in column 15. After all rows were evaluated, a tabular report was generated (Table 3-2). It listed all rows within the MA file that met the query specification with an affirmative response. Since the MA file in itself is a tabular representation of the CF data plane, the tabular listing is actually a summary of which CF regions met the query criteria.

After the tabular report was produced, the query procedure was directed to produce a map product to describe the result of the inquiry in a spatial context (Figure 3-1). IBIS program MAPGEN is used to map results of the query back onto the CF data plane. Briefly, the MAPGEN program operates in the following manner. MAPGEN checks the query attribute code stored in column 20 of the MA file for every CF data value coded in column 1 of the MA file. When MAPGEN finds a value 1 (true) in column 20, it would code all pixels contained in that region within the CF data plane a value of 1; and when false, a value of 0 would be coded for each pixel. Then, the resulting image would be contrast enhanced to enable visual discrimination between an affirmative or negative response. All regions meeting the query criteria were represented by a dark gray tone, while all other regions remained white.

In addition to the information depicted in the tabular report generated from the query, the mapped result of the query depicted in Figure 3-1 provides a spatial context for analysis as well.

Table 3-2. Tabular Report of All Land Use Areas Encoded with Land Use Label ACC

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

QUERY: ALL LAND COVER UNITS CODED ACC

LAND USE REGION	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
64	ACC	50	ABOV		1222	11.22	0.01753
77	ACC	50	ABOV	UIS	940	8.63	0.01349
86	ACC	50	ABOV		197	1.81	0.00283
87	ACC	50	ABOV	ACC	1188	10.91	0.01705
90	ACC	50	ABOV		2144	19.69	0.03076
98	ACC	50	ABOV		3687	33.86	0.05290
101	ACC	50	ABOV		2190	20.11	0.03142
105	ACC	150	ABOV		1689	15.51	0.02423
118	ACC	50	ABOV		134	1.23	0.00192
118	ACC	150	ABOV		1431	13.14	0.02053
140	ACC	50	BELO		6112	56.12	0.08769
140	ACC	50	ABOV		982	9.02	0.01409
140	ACC	150	ABOV		91	0.84	0.00131
141	ACC	50	ABOV		100	0.92	0.00143
153	ACC	50	ABOV		149	1.37	0.00214
153	ACC	150	ABOV		3178	29.18	0.04560
173	ACC	50	ABOV		447	4.10	0.00641
173	ACC	50	BELO		318	2.92	0.00456
173	ACC	150	ABOV		144	1.32	0.00207
174	ACC	150	ABOV		1733	15.91	0.02487
180	ACC	150	ABOV		2953	27.12	0.04237
187	ACC	150	ABOV		1308	12.01	0.01877
197	ACC	50	BELO		2849	26.16	0.04088
197	ACC	50	ABOV		1344	12.34	0.01928
200	ACC	150	ABOV		1357	12.46	0.01947
215	ACC	150	ABOV		1143	10.50	0.01640
					39030	358.40	0.56000

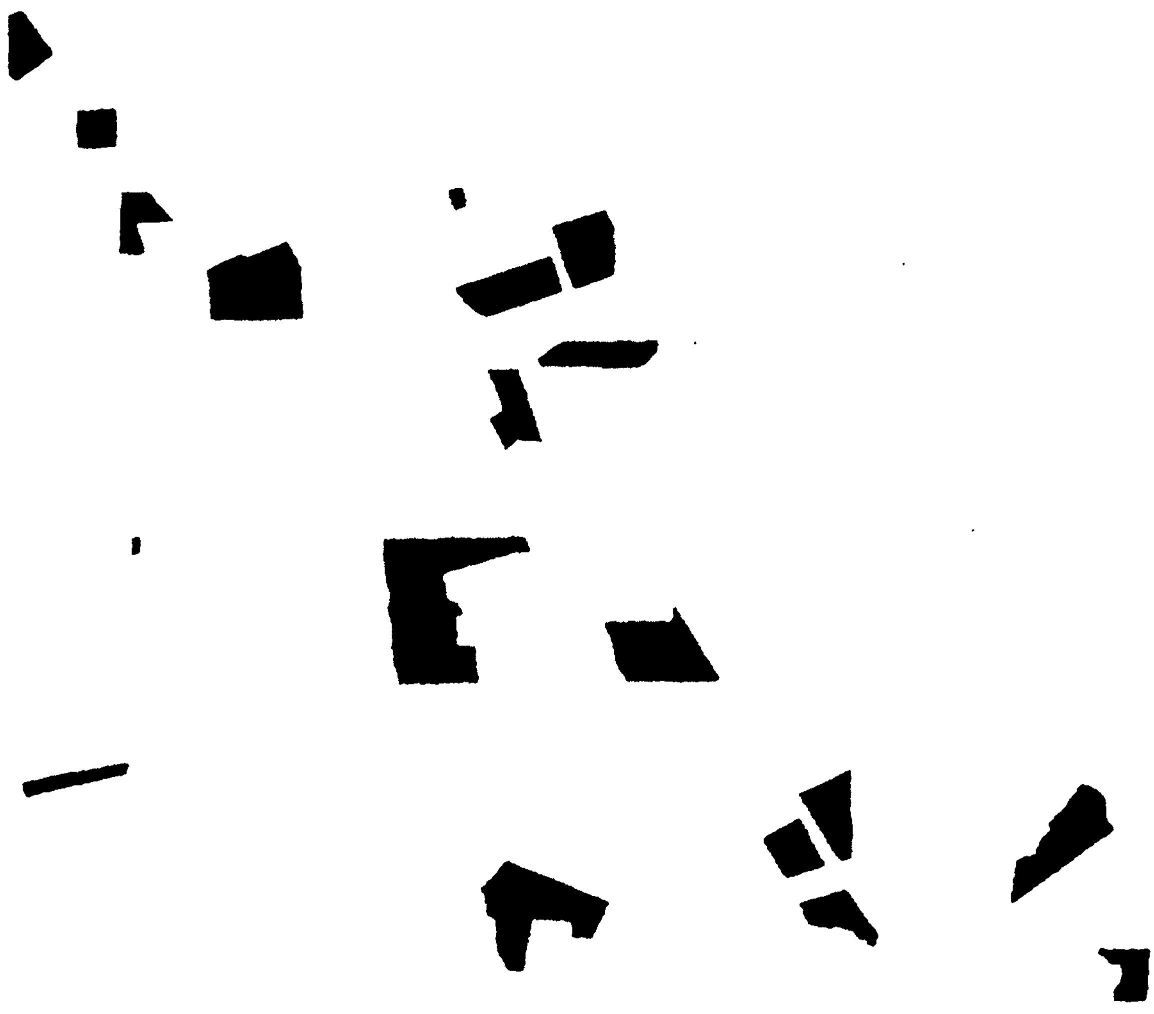

Figure 3-1. Thematic Map Depicting Regions Encoded ACC (produced by query of the data base)

The distribution of features meeting the query criteria are easily seen. However, even that map is hard to interpret because no reference is provided to identify the relationship between regions meeting the query criteria and those that did not. This problem was alleviated by adding a linear feature data plane, in this case land use region boundaries, on top of the query result (Figure 3-2). Now the analyst can gain a better perspective on exactly where the regions meeting the query criteria were actually located.

3.2.2 Other Query Examples

Queries can be formulated to check for attribute inclusion within a range of values instead of matching a single value. This type of expression would not be useful for processing nominal data; but when ordinal data are present, such an expression could be very useful. Consider the following question: Which areas are greater than 200 and less than 400 feet? The question is represented by the following query expression:

(C16 .GT. 2 .AND. C16 .LT. 4)

The query statement is interpreted to mean "all regions where the elevation attribute code is greater than 2 and less than 4." The mathematical formulation of the query statement would be:

$$2 < \text{elevation code} < 4$$

When values in column 16 fall between 2 and 4, the expression is evaluated true; and when values in column 16 fall outside of that range, the expression is evaluated false. The complete call to the query procedure is listed below:

```
CALL QUERY,FUN2,ALL AREAS BETWEEN 200 AND 400 FEET,MAP
P,FUN2
     '(C16 .GT. 2 .AND. C16 .LT. 4)'
```

As in the previous example, the a tabular listing (Table 3-3) and map (Figure 3-3) were derived from the execution of the query procedure.

Queries are not limited to posing questions based on data contained in a single column within the MA file. Queries can be formulated to involve multiple columns as well. For example, to map all areas within the floodplain but below 100 feet, the associated query statement could be formulated:

(C17 .EQ. 0 .AND. C16 .LT. 1),

where C17 .EQ. 0 and C16 .LT. 1 are two sub-expressions. The query statement is processed row-by-row as in the previous examples described. However, the internal processing is more complicated, actually requiring three evaluations for each row. Each of the two sub-expressions is evaluated independently, and then the composite expression is processed. The query expression is considered to true only when both sub-expressions are evaluated true. Luckily, the complexity of operation is invisible to the user. The results of the query were reported (Table 3-4) and mapped (Figure 3-4) as in the previous examples.

Figure 3-2. Map Depicting ACC Regions with a Land Use Outline Map as Overlay for Better Georeferencing

Table 3-3. Tabular Report of All Areas Greater Than 200 and Less Than 400 Feet in Elevation

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

QUERY: ALL AREAS BETWEEN 300 AND 400 FT

LAND USE REGION	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
6	UPS	350	ABOV		64	0.59	0.00092
6	URS	350	ABOV		13894	127.58	0.19935
6	UPS	350	ABOV		50	0.46	0.00072
9	R	350	ABOV		1203	11.05	0.01726
10	AVV	350	ABOV		8	0.07	0.00011
10	AVV	350	ABOV		124	1.14	0.00178
10	AVV	350	ABOV		366	3.36	0.00525
11	AVF	350	ABOV		573	5.26	0.00822
19	FO	350	ABOV		3349	30.75	0.04805
22	FO	350	ABOV		206	1.89	0.00296
26	R	350	ABOV		822	7.55	0.01179
29	URS	350	ABOV		504	4.63	0.00723
36	FO	350	ABOV		6093	55.95	0.08742
40	R	350	ABOV		2126	19.52	0.03050
51	R	350	ABOV		7725	70.94	0.11084
57	R	350	ABOV		979	8.99	0.01405
65	ACP	350	ABOV		3737	34.32	0.05362
84	AVV	350	ABOV		301	2.76	0.00432
110	ACP	350	ABOV		9204	84.52	0.13206
110	ACP	350	ABOV		33	0.30	0.00047
124	BT	350	ABOV		835	7.67	0.01198
124	BT	350	ABOV		94	0.86	0.00135
127	F	350	ABOV		761	6.99	0.01092
137	R	350	ABOV		1593	14.63	0.02286
					54644	501.78	0.78403

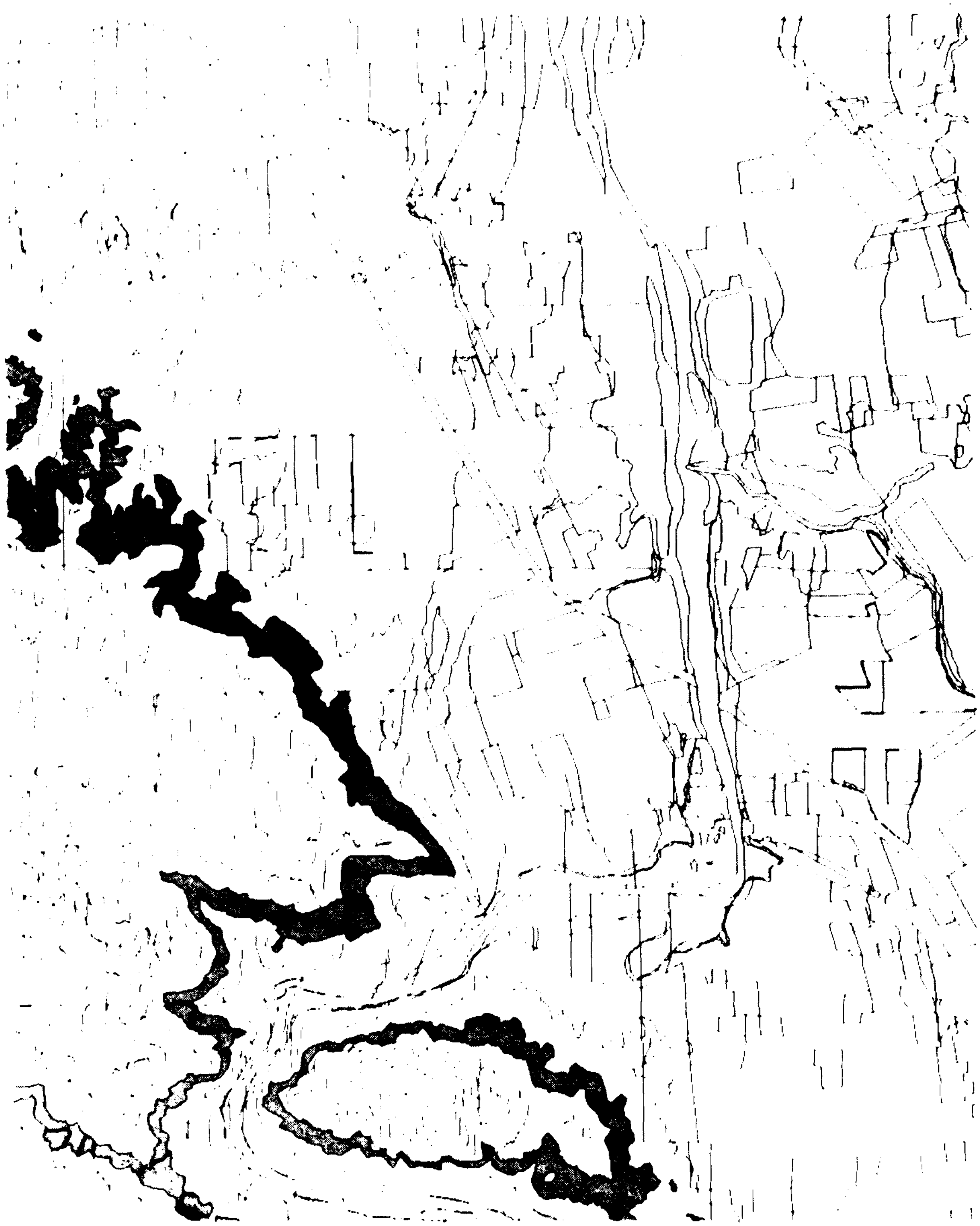

Figure 3-3. Map Depicting All Areas Greater Than 200 and Less Than 400 Feet in Elevation (land use line segments added for increased spatial understanding)

Table 3-4. Tabular Report of All Areas Within the Floodplain and Below 100 Feet (1 of 2)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

QUERY: ALL LANDS WITHIN FLOODPLAIN AND BELOW 100 FT

LAND USE REGION	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
3	URS	50	BELO		1191	10.94	0.01709
6	URS	50	BELO		3412	31.33	0.04896
7	WS	50	BELO		19591	179.90	0.28109
8	FO	50	BELO		1639	15.05	0.02352
9	R	50	BELO		35	0.32	0.00050
17	URS	50	BELO		392	3.60	0.00562
19	FO	50	BELO		153	1.40	0.00220
29	URS	50	BELO		425	3.90	0.00610
36	FO	50	BELO		354	3.25	0.00508
40	R	50	BELO		223	2.05	0.00320
41	AVF	50	BELO		12	0.11	0.00017
42	AVF	50	BELO		1196	10.98	0.01716
43	AVV	50	BELO		1223	11.23	0.01755
44	AVF	50	BELO		3174	29.15	0.04554
45	BT	50	BELO		449	4.12	0.00644
50	AVF	50	BELO		1796	16.49	0.02577
52	UUT	50	BELO		201	1.85	0.00288
58	LR	50	BELO		445	4.09	0.00638
61	UES	50	BELO		3843	35.29	0.05514
62	URS	50	BELO		584	5.36	0.00838
63	AVF	50	BELO		211	1.94	0.00303
63	AVF	50	BELO	AVV	97	0.89	0.00139
66	UOP	50	BELO		869	7.98	0.01247
70	UIS	50	BELO		686	6.30	0.00984
73	URH	50	BELO		121	1.11	0.00174
76	BES	50	BELO		781	7.17	0.01121
78	URS	50	BELO		505	4.64	0.00725
81	URS	50	BELO		297	2.73	0.00426
83	VV	50	BELO		658	6.04	0.00944
85	LR	50	BELO		333	3.06	0.00478
88	AVV	50	BELO	ACC	25	0.23	0.00036
91	WS	50	BELO		700	6.43	0.01004
91	WS	50	BELO	ACC	49	0.45	0.00070
92	LR	50	BELO		850	7.81	0.01220
93	AVF	50	BELO		366	3.36	0.00525
94	URS	50	BELO		74	0.68	0.00106
95	UUT	50	BELO		1290	11.85	0.01851
96	UOO	50	BELO		486	4.46	0.00697
97	LR	50	BELO		3930	36.09	0.05639
100	AVF	50	BELO		3544	32.54	0.05085
102	AVV	50	BELO	AVV	117	1.07	0.00168
103	AVF	50	BELO		2719	24.97	0.03901

Table 3-4. Tabular Report of All Areas Within the Floodplain and Below 100 Feet (2 of 2)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

QUERY: ALL LANDS WITHIN FLOODPLAIN AND BELOW 100 FT

LAND USE REGION	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
103	AVF	50	BELO	AVV	164	1.51	0.00235
104	ACP	50	BELO	AVV	125	1.15	0.00179
106	AVV	50	BELO		48300	443.52	0.69301
108	AVV	50	BELO		3673	33.73	0.05270
109	URS	50	BELO		790	7.25	0.01133
121	WS	50	BELO		830	7.62	0.01191
123	AVV	50	BELO		231	2.12	0.00331
125	AVF	50	BELO		6398	58.75	0.09180
130	AVV	50	BELO		578	5.31	0.00829
132	BBR	50	BELO		183	1.68	0.00263
135	AVV	50	BELO		918	8.43	0.01317
136	UES	50	BELO		4089	37.55	0.05867
138	AVF	50	BELO		400	3.67	0.00574
140	ACC	50	BELO		6112	56.12	0.08769
144	BBR	50	BELO		473	4.34	0.00679
146	AVV	50	BELO		11821	108.55	0.16961
147	UUS	50	BELO		1537	14.11	0.02205
148	AVF	50	BELO		52	0.48	0.00075
151	WO	50	BELO		3269	30.02	0.04690
152	AVF	50	BELO		459	4.21	0.00659
156	AVF	50	BELO		3931	36.10	0.05640
166	ACP	50	BELO		750	6.89	0.01076
172	UUS	50	BELO		24	0.22	0.00034
173	ACC	50	BELO		318	2.92	0.00456
177	AVF	50	BELO		4593	42.18	0.06590
183	AVV	50	BELO		942	8.65	0.01352
186	AVF	50	BELO		1371	12.59	0.01967
189	BBR	50	BELO		2295	21.07	0.03293
197	ACC	50	BELO		2849	26.16	0.04088
199	URS	50	BELO		249	2.29	0.00357
210	LR	50	BELO		827	7.59	0.01187
211	AVV	50	BELO		1626	14.93	0.02333
216	BEQ	50	BELO		1441	13.23	0.02068
218	WO	50	BELO		798	7.33	0.01145
222	AVF	50	BELO		3802	34.91	0.05455
229	AVV	50	BELO		869	7.98	0.01247
					176133	1617.37	2.52713

Figure 3-4. Map Depicting All Areas Within the Floodplain and Below 100 Feet, an Example of a More Complex Query

3.3 EVALUATION OF THE BATCH QUERY PROCEDURE

The IBIS data base query procedure described in this section involved the execution of a stored sequence of batch-entry job steps that operated on a specific data base defined by the CF data plane and the MA file. It proved to be an effective means to pose queries to a complex data base. The results of the query, a tabular report and an optional map, were quite useful for geographic analysis. The procedure represented a major increase in the capability to analyze the relationships between the distributions of different data types.

Several aspects of the original query procedure made it unwieldy to utilize. A significant amount of detailed preprocessing of all input-coded data planes was required to produce the CF data plane. This process, involving the combination of those data planes into a single data plane, represented a major investment in time. Once the CF data plane was completed, it could not be modified. If the user of the data base wanted to incorporate other data planes in addition to, or as replacements for, those previously included, an entirely new CF data plane would have to be generated. Consequently, when considering the need to maintain data bases with current information, maintenance of the CF data base represents a costly as well as a time-consuming effort. Also, the inevitable complexity of the CF data base had to be considered, since IBIS has a limit on the number of geographic regions (currently 100,000) that can be included in any one coded data plane. This ceiling on the number of regions would be rapidly approached whenever the number of data planes to be included in the data base would increase or the spatial extent of the study area would be expanded. In retrospect, it would seem more advantageous not to build the CF data plane at all and maintain the individual coded data planes for query. Again, this could not be easily accomplished without writing new software.

In addition to building a CF data plane, an MA file had to be constructed from the various source attribute files associated with each of the input data planes. This was also a complex process and involved the execution of many computer programs. Additionally, another major drawback of the batch query approach was the requirement levied upon the analyst for maintaining detailed ancillary notes about the MA file contents. Before any query could be executed, a written directory of the MA file had to be prepared by the analyst. Detailed lists would also have to be prepared by the analyst to describe the types of attributes that would be found in the MA file. No automated method was available to store and access such reference information. Such a feature was needed. To further compound problems with the use of the MA file, only those columns that contained numeric data could be utilized in a query. This meant that all alphabetic labels and descriptors had to be assigned a unique numeric code in an additional column before the information could be queried. Not only was a file directory required in such cases, a complete table depicting the association between all alphabetic labels and their respective numeric code equivalents had to be prepared for each column of alphabetic data. The capability to process textual information would be considered a great improvement.

The development of the actual query processing statement was also complicated. The rules of syntax were simple, but nonetheless, they were often violated. Diagnostic messages did not indicate the source of or solution to the error. The program would just end with an abnormal termination statement. The consequence of this condition, added to the other aforementioned characteristics, was that the original batch-version query was not easily used. Use of the procedure required extensive data base preparation time, necessitated a detailed understanding of the MA file contents, and was based on an unfriendly query statement syntax.

Still, the original query procedure did represent a major improvement in the capability to understand the distribution of spatial data. The procedure was later modified to operate as an interactive procedure. This basically allowed the analyst to run queries in a near-real-time mode and obtain results of the query on a display monitor. The capability to run VICAR procedures interactively was quite limited, though, and plans were made to develop a completely new approach to query processing. In conclusion, the query procedure was an effective learning tool. It was used to point out what features should be included in the new query program.

SECTION 4

INTERACTIVE QUERY OF IBIS DATA BASES

A Geographic Information System (GIS), like any data base management system, should include user-friendly features for data entry, data base maintenance, and data base query. Historically, IBIS has included methods to enter, maintain, and manipulate IBIS data bases (Friedman, 1980). However, as alluded to in the last chapter, those methods have not necessarily been user-friendly, especially with reference to processing data base queries. Additionally, IBIS data base queries could not even be run until an extremely cumbersome data base preparation procedure was completed. Submitting queries also required the development of syntactically complex query statements. In order to be truly effective and to facilitate its utilization, a completely restructured data base query methodology had to be developed. This new procedure is described in this section.

In developing the new upgraded version of QUERY, most of the disadvantages described at the end of Section 3 have been addressed. No longer are composite feature data planes necessary for the process, as the new version allows simultaneous processing of a number of independent data planes. Also, the development of the MA file is not required, as the new program can process an independent attribute file for each data plane input. The analyst is not required to produce an MA file directory, since the software displays a table of contents for all tabular files input. Alphabetic data can be used to formulate more readily understood query expressions. Additionally, in the process of its amelioration, the earlier, strictly batch-entry query has been transformed into an interactive program. All of these changes have made the query process much less laborious and detailed to use and has provided for significant improvements in the capability to employ the software for straightforward GIS processing.

The initial steps in the new interactive query process dealing with data base preparation are in general identical to the procedures described in Section 2 of this document. However, there is no need to develop either the CF data plane or the MA file, as queries can be posed directly to IBIS PDS (paired-data sets) with the new software. Each PDS is composed of a Coded Data Plane and its attendant attribute file. Once the PDS are prepared, they can be input as discrete data set pairs into the query program. The analyst can then manipulate those files in a number of different ways through the issuance of query statements. With the new query software, the inquiry can be processed quickly and displayed on a video monitor.

The Healdsburg data base, developed to demonstrate the first batch query proc dure, was utilized to test and demonstrate the new query software. As covered previously, the CF data plane and MA file were not included in the data base, as they are no longer needed for the new software. Only the four original IBIS PDS were used. Again, the four themes available for analysis are: (1) land use, (2) 100-foot elevation zones, (3) 100-year floodplain, and (4) land use revisions. The organization of the four original attribute files was modified slightly to facilitate the new application. After reorganization,

each of the four files contained four columns. The first column contained region codes representing the encoding structure of the data plane. The second column contained labels in textual form used to describe attributes of those regions, while column three contained numeric attribute codes used during the previous application of the batch query procedure. Finally, column four contained pixel counts that could be used to determine the sizes of the various geographic regions included in each data plane.

4.1 INTERACTIVE QUERY SOFTWARE

Once all input data sets for a given study area have been prepared, the data base can be readily queried by an analyst. As a first step in analysis, it is a good idea to formulate the specific objectives of the query session. It may be useful to prepare a statement in English describing the information to be extracted from the data base. Similar to query statement processing for the batch query, this statement cannot be directly interpreted by the interactive query processor. But its formulation is still useful, since the specific objectives of the query session will have been defined. To undergo query processing, the statement must be translated into one or more expressions that can be efficiently interpreted and processed by the computer software.

The task of translating statements from English into a language interpretable to the query software involves a knowledge of query statement construction conventions. One of the main purposes of developing this new query software was the reformulation of standards to govern expression syntax. In its redesign, an attempt was made to balance the user's need for simplicity with the requirements of minimal and straightforward computer processing time. To this end, a formal yet flexible query grammar, or syntax, was created. A detailed description of the syntax and query expression development is covered in the following two portions of this section.

4.1.1 Query Expression Components

Syntactically, a query expression is similar in construction to a mathematical formula or to an arithmetic statement used in FORTRAN (Table 4-1). However, more flexibility has been provided for query statement development than is generally available from FORTRAN. The components of a query expression are <u>operators</u> and <u>operands</u>, which are combined logically into a sequence to yield the desired results. An <u>operator</u> indicates what action is to be performed in the expression. The operator is analogous to a verb in the query grammar. <u>Operands</u> can be likened to nouns, and as such are the objects to be acted upon in the query statement.

At the most basic level, operators are placed between two operands and indicate what action is to take place. In the expression <u>A + B</u>, the operator symbol + indicates that the contents of operand A are to be added to those of operand B. In the context of query, the addition operator is referred to as an <u>algebraic</u> operator. Other operators of this class include those standard to FORTRAN, -, /, and *, which indicate subtraction, division, and multiplication, respectively. In all cases, the algebraic operators yield numeric output from their operands when evaluated in an expression. When there is more

Table 4-1. Query Statement Components

Basic Structure: (VO {OP} CO) or

Compound Structure: (VO {OP} CO) LO (VO {OP} CO) where:

VO = Variable Operand: Represents operands stored in an attribute file. They are considered variables, since their values change with each evaluation of the query expression.

CO = Constant Operand: Represents operands provided at the time of query to compare to variable operands contained in an attribute file. They are referred to as constant operands because they remain a constant value for all evaluations of a query expression.

OP = Operator: Represents operators that define how VO's (variable operands) and CO's (constant operands) are to be compared or processed. Operators may be selected from the following list:

Algebraic Operators:

+	-	*	/	(FORTRAN form)

Relational Operators:

<	>	=	<=	>=	<>	(symbolic form)
LT	GT	EQ	LE	GE	NE	(FORTRAN form)

Math-Library Operators:

SQRT ALOG ALOG10 AINT ATAN2 ABS SIN COS
TAN ASIN ACOS ATAN MIN MAX AMNI
AM AXI MOD AMOD

LO = Logical Operators: Represent operators used to link two or more simple query expressions. Valid logical operators include:

Logical Operators:

AND	OR	XOR	NOT	(FORTRAN form)

---

than one operator in an expression, the FORTRAN standard order of operator execution is followed. As in FORTRAN, this order can be changed with the addition of hierarchy-establishing parentheses "()." Thus the expressions A + B * C and (A + B) * C are not equivalent, since without parentheses the multiplication of B and C has priority and is executed first, then A is added to their product. In these respects, as in others previously mentioned, the query syntax conforms to normal FORTRAN conventions.

Another group of operators, the relational operators, are used to make comparisons between two operands. The operator LT in the expression A LT B is equivalent to the mathematical symbol < and tells the computer to identify all situations where operand A is less than operand B. In addition to LT, the relational operators available to formulate query expressions are: LE (less than or equal to); GT (greater than); GE (greater than or equal to); EQ (equal to); and NE (not equal to). As with the algebraic operators, the use of relational operators follows the conventions of FORTRAN. However, as an added feature, conventional mathematical symbols may be used in place of text operators. The following symbols, <, >, <=, >=, =, and <>, are equivalent to, respectively: LT, GT, LE, GE, EQ, and NE in query statement construction. The products of relational expressions are binary (either 0 or 1) based on conditional evaluation of the expression. When the expression "A<B" is evaluated to be true, the resultant product is 1; and when false, the resultant product is 0.

Logical operators, the last remaining group of query operators, are used for Boolean-type queries. AND is a logical operator, and in the expression "A AND B" it is used to check for the condition in which both A and B are found to be true. A AND B is equivalent in mathematics to $(A \cap B)$. Other logical operators, OR, XOR, and NOT, are also accepted in query expressions. As with relational operators, these operators yield binary results. Their effects are best portrayed in Venn diagrams (Figure 4-1).

During the course of executing a data base query, the user actually accesses and queries the input data sets through the issuance of query statements. Thus, the specific coded data planes, the columns of attribute files with various attributes, must be readily identifiable to the user. To facilitate this, symbolic names or labels are assigned to each data plane, attribute file column, and attribute. Usually, the symbolic names indicate the contents of the file or attribute column. The symbolic name RES, for example, would be a logical choice for the attribute residential contained within a column labeled LU for Land Use.

These symbolic names are considered operands when used in a query expression. Those operands representing a data plane or an attribute file column can be thought of as variables whose values change with each evaluation of the expression. The values of attributes, however, do not change and thus they are considered constants for any given query operation. Operands must be divided into two categories, variables and constants, because query expression syntax has certain rules about variable-operand and constant-operand positioning in a statement. In addition to the operands just described, integers and real numbers that are considered as constants are also valid query operands.

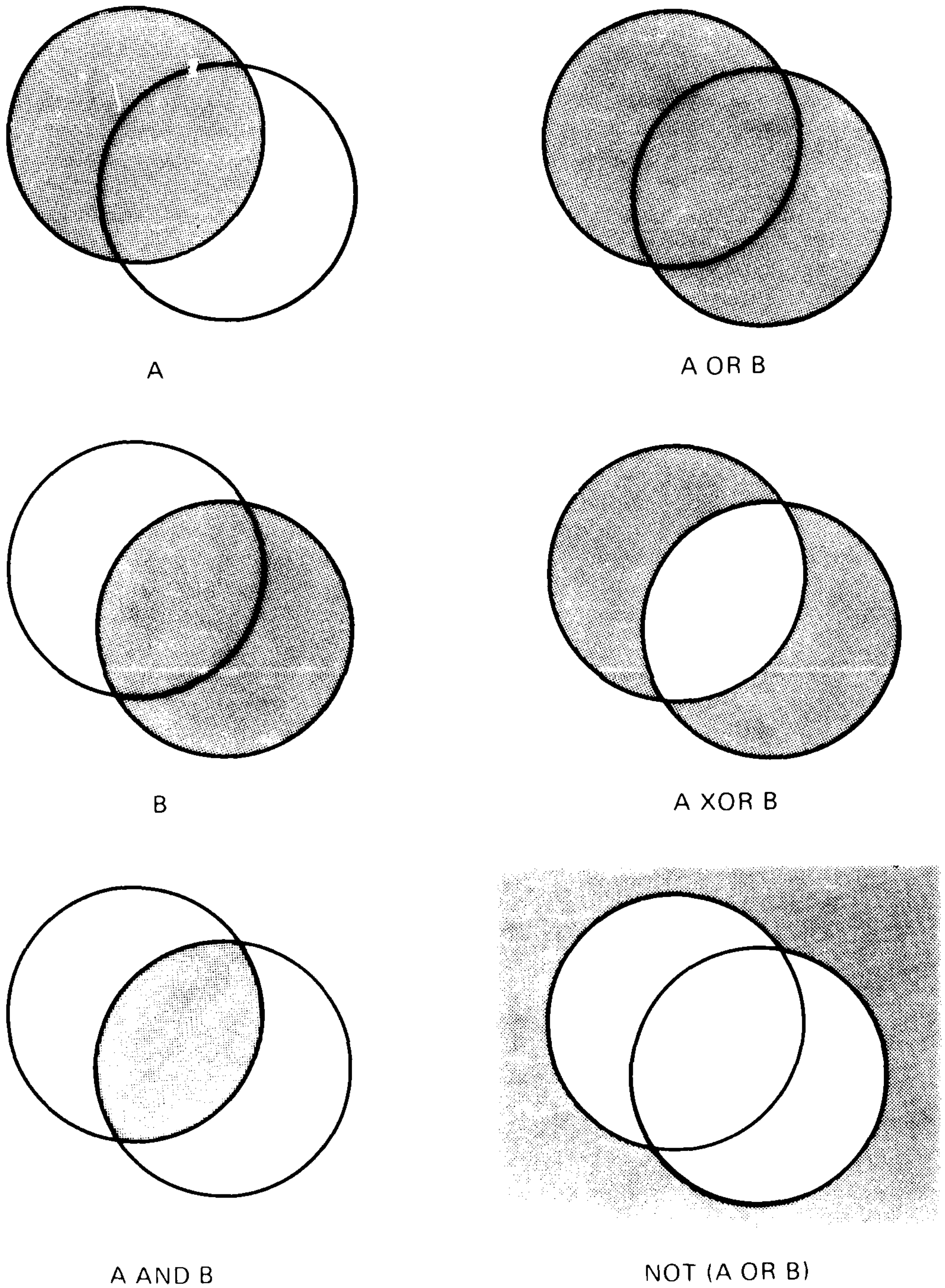

Figure 4-1. Venn Diagrams Depicting the Logical Associations Between Two Sets, A and B

4.1.2 Query Statement Structure

A query expression is a logical sequence of operators and operands that is interpreted and processed by the computer to yield an output data set. This output is itself a coded data plane that can be composed of either a binary or numeric response. For binary responses, eight bit planes are available for output. When a numeric response is specified by the query expression, the same bit planes are all combined in constructing a product image. An entire query statement consists of (in sequential order): (1) the data plane to receive the output; (2) a colon ":", and (3) the expression to be evaluated.

The output plane is represented by the symbolic name L or Ln, where n is a value between one and eight. When L is used without a subscript designator, all eight-bit planes are combined to form a single eight-bit image to receive a numerical product. If one of the symbolic names Ln is specified, for example, L6, it indicates which one of the eight possible bit planes is to be used for the binary output.

The main part of the query statement consists of the operators and operands to the right of the colon. Although a wide range of valid operator/operand strings can be constructed, many possible combinations are esoteric and very unlikely to be used for applications. In the interest of brevity and simplicity, only the more commonly used structures are described. It should be noted, however, that the syntax-governing rules given apply to any valid query expression.

The most commonly used basic expression form is an algebraic or relational operator linking two operands. With an algebraic operator, such an expression yields numerical output, whereas a relational operator results in binary data. At this level, one rule must be adhered to: The first operand must be of the variable type, and the second operand must be of the constant variety. At the outset, this may appear to be complex, and the distinction between constant and variable operands may appear to be reversed. But in actuality, the development of query statements is not very complicated. As an example, if LU is a symbolic name for a tabular file column of land use, and RES is the name for LU's residential attribute, then the statement

L1:LU EQ RES

would be a typical query statement. In this example, the column name LU is considered the variable operand and attribute name RES is the constant operand. Execution of this particular expression would yield binary results in the first bit plane L1 of the output data set. All areas of residential land use would be flagged, with the value one (1) representing a true condition, and those of a different land use as zero (0), for a false condition.

The generalized basic query expression structure can be characterized by

(VO {OP} CO)

where VO is the variable operand, OP is either an algebraic or a relational operator, and CO is a constant operand. Quite often, two or more of these basic structures are linked together by logical operators to form more complex expressions. Expanding on the previous example, the expression

L1:(LU=RES) and (ELEV=150)

might be used to find the areas in the data base that are both residential in their land use component and are identified as being 150 feet in their elevation component. Compound expressions such as this formed with logical operators yield binary output. Thus query expressions often take the form

(VO {OP} CO) LO (VO {OP} CO) . . .

where LO is a logical operator. Note that the logical operators link two or more of the basic expressional structures but are never used to link operands found at the sub-expression level.

Two special cases of implicit operands are worth noting. They were developed to shorten and streamline query statement development. First, the expression

(ELEV>=50) AND (ELEV<=250)

could be shortened to

(ELEV>=50 AND <=250)

and still yield the same results. In such a case the variable operand ELEV is inferred a second time by the computer without having to be stated explicitly. Second, the expression

(LU EQ ACC) OR (LU EQ AVV) OR (LU EQ UCC)

can be shortened to the phrase:

"LU EQ ACC;AVV;UCC"

and still yield the same result. The semicolon (;) will be replaced logically by an OR, the variable operand, and the operator forming OR LU EQ during query statement evaluation. These added features make query statement formation an easier task when long, repetitious phrases are to be evaluated.

By comparison, the same expression could have been developed with the batch query procedure, but it would have been more complicated:

(COL15 .EQ. 1) .OR. (COL15 .EQ. 5) .OR. (COL15 .EQ. 14)

Certainly the new query syntax is simpler to use and is less prone to analyst error.

4.1.3 Query Statement Processing

The new query software is a large interactive program designed to interpret, process, and display queries. The program is partitioned into three central processors: the command processor, the evaluator, and the display processor. The query program accepts instructions from the user via the command processor. The command processor decodes and validates commands and then passes control to the appropriate command-invoking subroutine. The commands currently available are:

QLA	=	List attributes
QE	=	Enter query expression
QP	=	Process all query expressions
QLE	=	List unprocessed query expressions
QLP	=	List processed query expressions
QHELP	=	List available query commands (Help)
EXIT	=	Exit query program

These commands are explained in detail below:

QLA = List attributes

This command causes a list of available data sets and associated attributes to be displayed. The module is entered automatically when the query program is first invoked. During the first execution of this command, all the data sets are opened and the label records are scanned for attribute names. During subsequent executions of this command only, the attributes are displayed on the user screen.

QEn = Enter query expression

To enter a query, the user enters the command QEn, where n is an integer from 1 to 8, representing a query buffer. Then the user is prompted to enter a query expression. The expression is stored in a QE buffer n named in the QE request. Up to eight statements can be stored in QE buffers one through eight. First, the expression is checked for proper syntax; then it is scanned and translated into a form suitable for repeated evaluation by the QP module described below. During the scan, operators are located by comparing the expression components to a table of valid operators. Variable operands are located by comparing remaining components to a table of variables. Any remaining operands are assumed to be constants.

QP = Process all query expressions

This command designates that the query evaluator processor is to be invoked. This command causes all expressions currently entered with the QE command to be evaluated. Each expression is evaluated at each pixel location using the variables associated with that pixel location. When multiple expressions are processed, the expressions are executed in sequential order, starting with expression one and ending with expression 8. As each expression is evaluated, the

results are placed in the output image, at the same corresponding pixel locations. The output bit planes are selected L1 through L8 to match the bit planes identified in the query expression. After the processing is completed, the number of output pixel locations where the query statement was evaluated to be true is reported for each output image. Finally, the QE buffers are cleared, after all expressions just processed are transferred into the QP buffers for subsequent reference.

QLE = List unprocessed query expressions

This command is entered to display the current expressions in the QE queue for processing.

QLP = List processed query expressions

This command will cause the display of the most recently processed expressions for each output bit plane or image.

QHELP = List available query commands

Enter QHELP will yield a display of all the commands that the query software currently supports.

EXIT = Exit query program

This command is used to terminate the query processing. EXIT closes all data sets and exits the program.

4.1.4 Display Capabilities

In addition to the commands described in the previous section, the upgraded query software also enables interactive examination of both input and output data planes on a display screen. This display-oriented component of the query software was implemented with features to accommodate the user. It enables the user to specify the positioning of the desired data planes on the screen as well as the scale at which each image is to be displayed. These data planes can also be contrast stretched to enhance areas of particular interest to the user. All of these capabilities facilitate the viewing of multiple data planes at a single instance. The specific display commands are not essential to describing query functionality. They are described in documentation for VICAR program IDISPLAY, which is the interactive display workhorse for VICAR. The reference is made here only for purposes of providing a complete picture of query capability.

Peripherals to the display screen, such as the Dunn camera, can be attached to the display device and used to make quick-developing photographic prints of the screen. For a higher quality, though slower turnaround-time product, the data sets can easily be copied to a magnetic tape or disk and played back on a film recorder. Both the on-line camera and the off-line film recorders offer the user uncomplicated means of obtaining hard-copy outputs from the query session.

4.2 EXAMPLE OPERATIONS OF THE NEW INTERACTIVE QUERY SOFTWARE

A list of data base query objectives was conceived to test the query software by simulating a real query session. The queries included:

(1) Find all land use regions labeled ACC.

(2) Find the regions within the floodplain that are also below 100 feet.

(3) Using the results of the two previous queries, find all land use regions coded ACC that lie within the floodplain and are also below 100 feet in elevation.

The following paragraphs provide an account of the interactive processing steps used to determine the results for those queries.

4.2.1 Initiation of the QUERY Program

The four IBIS PDS associated with the Healdsburg data base were opened and made available for processing with the following command statement:

```
EXEC,QUERY,(LU,LUATT,EL,ELATT,FLD,FLDATT,LUR,LURATT),PRODUCT
```

The command identified the operation of program QUERY, the eight data sets available for analysis, and the name of the data set where query products can be saved. The four region-coded data planes LU, EL, FLD, and LUR represent land use, elevation, floodplain, and land use revision, respectively. Each associated attribute file is represented by LUATT, ELATT, FLDATT, and LURATT in the same order.

4.2.2 Displaying Reference Information

Once the data sets are opened for processing, the analyst is prompted to enter the next command. The analyst entered QHELP to review query processing options. The query program responded by providing a list of available query commands with short descriptions (Table 4-2).

Table 4-2. Query Commands Available to the Analyst Are Listed by QHELP Command

QUERY COMMANDS

QLA	LIST ATTRIBUTES
QE,NO.	ENTER EXPRESSION(1-10)
QLE	LIST EXPRESSIONS
QP	PROCESS EXPRESSIONS
QHELP	LIST QUERY COMMANDS
EXIT	EXIT PROGRAM

Then the user decided to see a list of data sets and attributes available for expression analysis. The QLA command was entered, and a list of available attributes was produced (Table 4-3). The column labeled DATASET NAME lists the logical names of the four coded data planes available for processing. The column labeled ATTRIBUTE NAME lists the logical names of attribute file columns that can be used to develop query expressions. (The names found in these two columns become the variable operands in the query expression.) The final column, labeled DATA TYPE, is used to define the type of data, either textual (TEXT) or numeric (NUM), contained in each corresponding data set or attribute reference. That information is provided to enable the analyst to formulate meaningful statements.

4.2.3 Development of QUERY Statements

The analyst now decides to develop query expressions to satisfy the three topics listed previously. The analyst enters QE1, which identifies the first expression to be input. The computer responds with the prompt "ENTER EXPRESSION." The analyst enters the expression to find all land use regions coded with the attribute ACC:

L7:LU=ACC

Table 4-3. A List of Available Attributes is Produced by the QLA Command

DATASET NAME	ATTRIBUTE NAME	DATA TYPE
LANDUSE		NUM
	LU	TEXT
	CODE	NUM
	COUNT	NUM
FLOOD		NUM
	FLD	TEXT
	CODE	NUM
	COUNT	NUM
ELEV		NUM
	EL	TEXT
	CODE	NUM
	COUNT	NUM
LUREV		NUM
	LUR	TEXT
	CODE	NUM
	COUNT	NUM

The expression results will be placed in bit plane number 7. After the expression is entered, the query program evaluates the statement for syntax. If an error is found, a diagnostic statement is provided and the analyst is again prompted to enter an expression. When no errors are found, the user is prompted for the next command.

The same sequence is followed to generate the next two query statements, after which the analyst wishes to review all three of the expressions entered (Table 4-4) by entering the QLE command. The second query,

L6:FLD=BELO AND ELEV.CODE<100,

is a complex query involving two evaluations. The first condition, FLD=BELO, and the second condition, ELEV.CODE<100, must both be evaluated true in order for the complex expression to be true. Also note that since the attribute designation CODE is not a unique attribute name, the variable operand must be designated by a more complete reference ELEV.CODE. The final query expression

L8:L7 AND L6

designates that the results of the two previously evaluated query expressions are to be compared. Since queries are processed in order of occurrence of the list, values for bit planes 6 and 7 are compared. Whenever both bit planes contain a true response, L8 is evaluated true as well.

4.2.4 QUERY Processing

Now the analyst directs the QUERY program to process the three queries by issuing the QP command. The program responds with the reply "QP IN PROGRESS," and then it processes the query expressions in order, QE1, QE2, and then QE3, for each pixel in the data base. After completion of the final evaluation, the program lists the number of pixels that were evaluated true for each query followed by a summary of central processing unit (CPU) time used for all evaluations. (Table 4-5). The analyst then decides to list all processed queries by entering the QLP command, causing the final list to be produced (Table 4-6).

Table 4-4. List of All Expressions To Be Processed

	EXPRESSIONS TO BE PROCESSED
QE1	L7:LU=ACC
QE2	L6:FLD=BELO AND ELEV.CODE<100
QE3	L8:L7 AND L6
QE4	
QE5	
QE6	
QE7	
QE8	

Table 4-5. Results of Query Processing

QP FINISHED

L7	38950
L6	175725
L8	9205
CPU TIME =	7 MIN 04 SEC

Table 4-6. List of All Processed Queries Obtained from Issuing the QLP Command

PROCESSED EXPRESSIONS

L
L1
L2
L3
L4
L5
L6:FLD=BELO AND ELEV.CODE<100
L7:LU=ACC
L8:L7 AND L6

The analyst can display the results of any of these queries by using either the display processor or a hard-copy generation device. The results of the three queries are included here (Figures 4-2 to 4-4).

For purposes of verifying the accuracy of the query software, those output data planes were checked at every stage in the process against hard-copy versions of the data planes comprising the Healdsburg data base. Thus the performance of the query software was evaluated independently of the computer data base.

No problems were encountered while each individual query was being processed. All of the output data sets had the correct areas flagged to reflect the query. Through the use of the display capabilities, the output data planes appeared on the screen in a matter of a few seconds. Hard-copy products used in this report were made directly off of the screen with a Dunn camera, or data were transferred to magnetic tape and subsequently processed on a film recorder.

Figure 4-2. Result of Query: Land Use Equals Code ACC

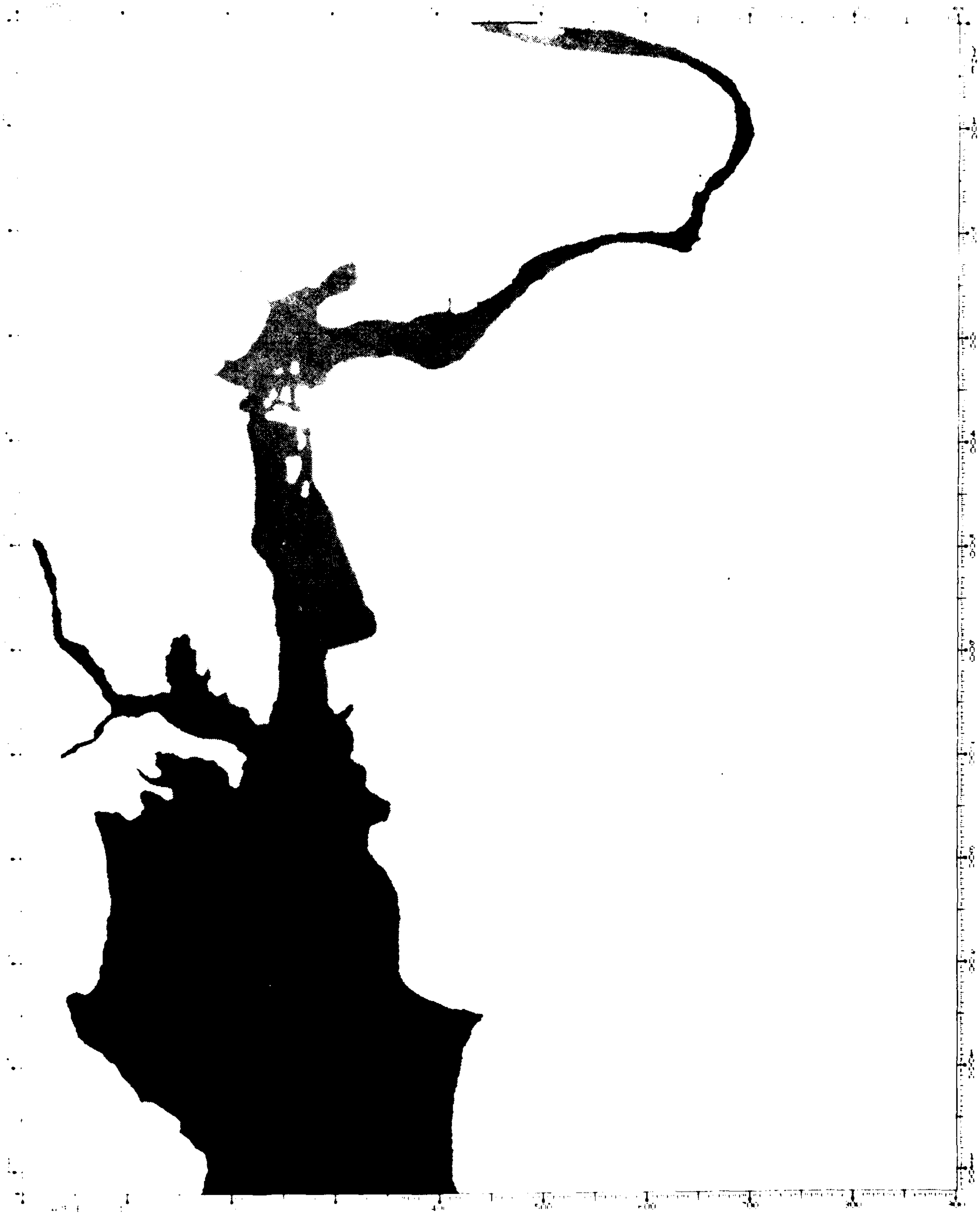

Figure 4-3. Result of Query: FLD=BELO and ELEV<100

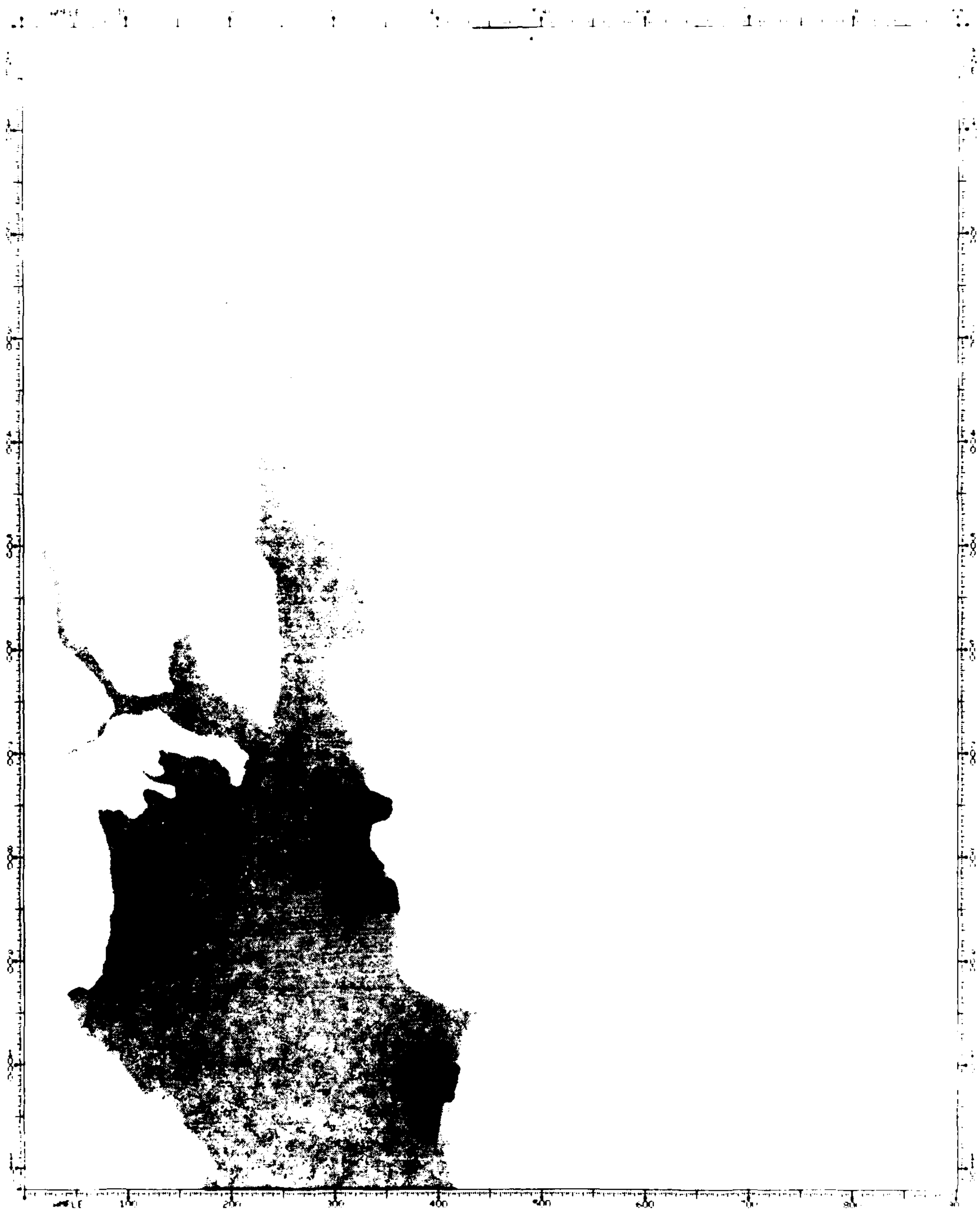

Figure 4-4. Result of a Query by the Composite Query Process
All land areas coded ACC, within the floodplain, and below 100 feet. The first query, LU=ACC, is depicted in the lightest tone. The second query, FLD=BELO and ELEV<100, is depicted by the medium gray tone. Finally, the composite of the two queries is depicted in black.

4.3 EVALUATION OF THE INTERACTIVE QUERY PROGRAM

The new query software represents a major improvement over the original batch-entry process and the first interactive version. However, one feature of the original query program was not included in the software redesign. While the batch version of the software provided a tabular report covering the results of the query, the new interactive version does not. The batch method relied on several IBIS programs, including AGGRG, AGGRG2, TRANSCOL, REPORT, and ROWOP, to produce the report. The features of those programs could not be implemented with the new software during the period available for the query redesign. However, the features offered by the tabular report were always considered to be quite useful and beneficial, and it would be hoped that a similar report function could be eventually added to the new query program.

Several other features could be added to the query software to promote its wider application and versatility. The current data structure convention limits attribute file columns that contain character information to be formed by a field of exactly four characters. This convention restricts the use of attribute labels in QUERY to labels of four characters or less. Since many attributes cannot be properly identified by only four characters and still maintain some form of understandability, IBIS attribute file conventions must be modified to accomodate variable dimensioned column fields. This software improvement was not undertaken at this time, because more than forty other IBIS programs that utilize IBIS attribute files would need to be modified as a result. It is important to note that some improvements to the attribute file structure were made to support the QUERY software, with the inclusion of both column name and column data-type blocks within the attribute file label. This improvement was made without affecting the operation of other IBIS programs that process interface files.

A timing analysis on the performance of the new query processor was made (Appendix A, Table A-1). The timings for queries involving single, double, or even more data planes seems to be a fairly constant function. Each data plane for the Healdsburg data set measured 900 x 1120 pixels for a total of 1,008,000 pixels. For a query involving just one image plane, execution time ran about 2.3 CPU minutes. For queries involving analysis of multiple image planes the processing time in minutes has been estimated to conform to the equation

$$1.38n + .58$$

where "n" is the number of data planes analyzed. Thus, for a query involving two data planes, the processing time usually ran about 3.25 minutes. A query involving five image planes ran in just over 7 minutes. At the data processing rate of 1,008,000 pixels in 2.2 minutes, more than 7,600 pixels were processed each second. Some software optimization routines were developed during the course of this program development, but additional modifications could greatly improve processing time. Since the query program is an interactive procedure, any improvement in processing time would be beneficial to the user, who must wait for the process to be concluded. (Since QUERY is operated in a time-share environment, it is not unlikely that the analyst will have to wait more than three times the CPU execution time for the completion of the process.) Perhaps a new data structure involving the representation of the data in a more compressed form would also increase efficiency and hence improve processing time.

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APPENDIXES

APPENDIX A

Sample Query Products From Interactive Query

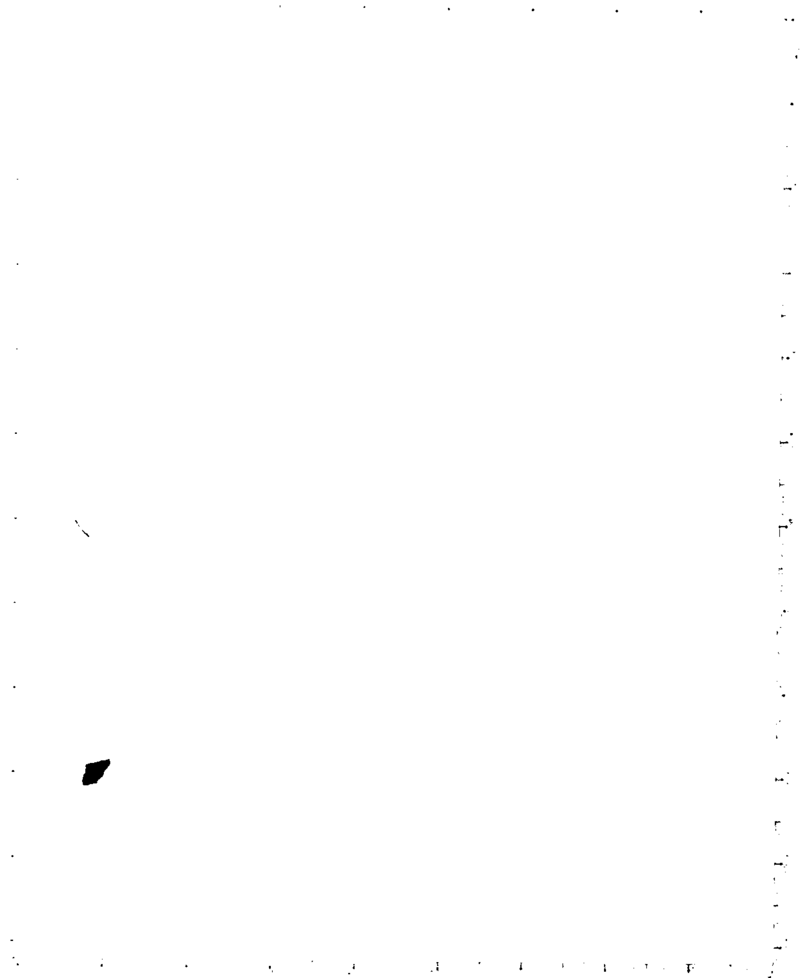

Figure A-1. Result of Query: LU=ACP AND FLD=BELO

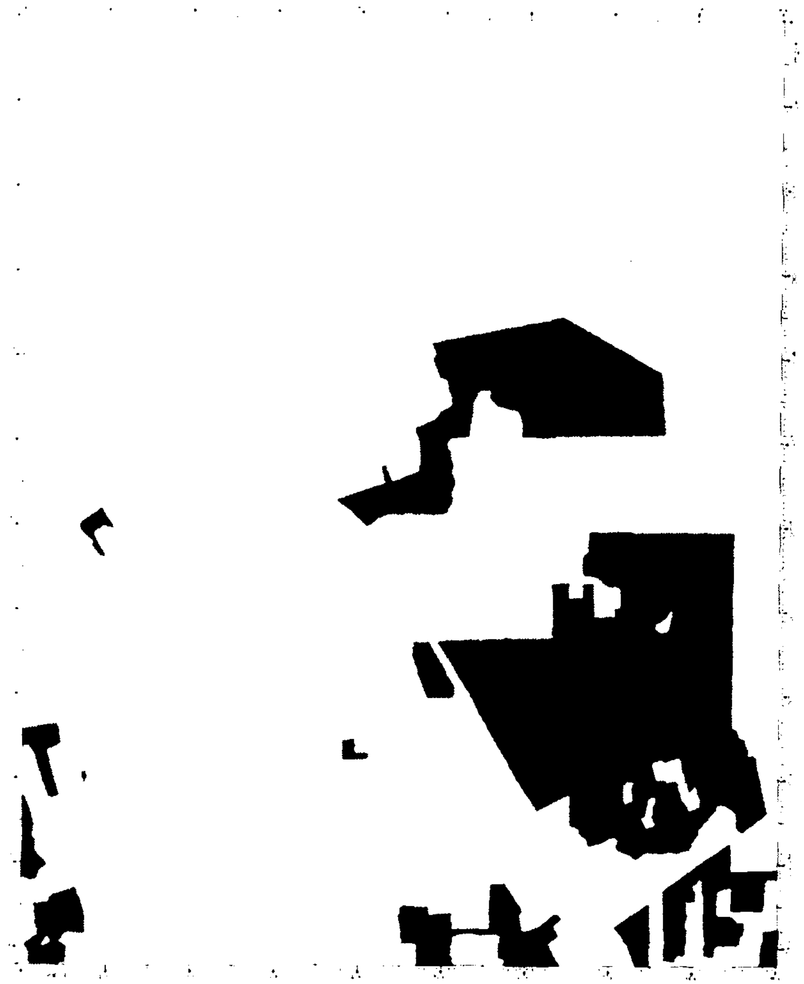

Figure A-2. Result of Query: LU=ACP AND FLD=ABOVE

Figure A-3. Result of Query:
LU=ACP AND ELEV.CODE GE 3

Figure A-4. Result of Query: LU=ACP AND
(ELEV.CODE>=3 AND ELEV.CODE<=5)

Figure A-5. Result of Query: LU=ACP AND (ELEV.CODE<=2 OR ELEV.CODE GT 5)

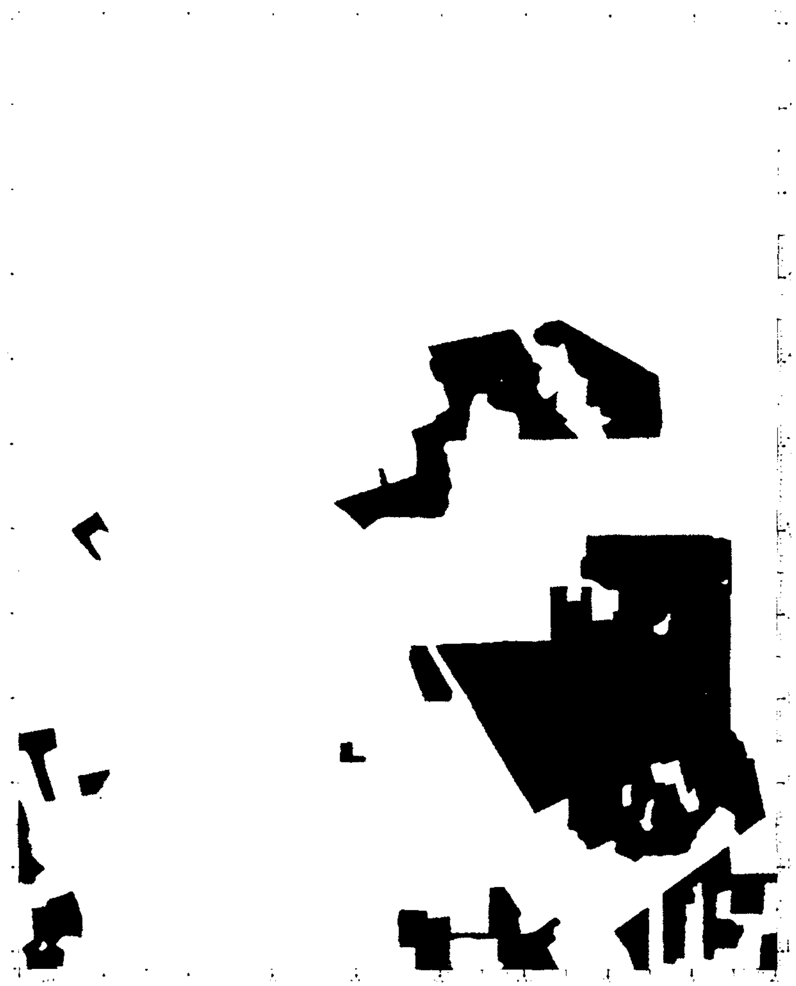

Figure A-6. Result of Query: LU=ACP AND ELEV.CODE<>5

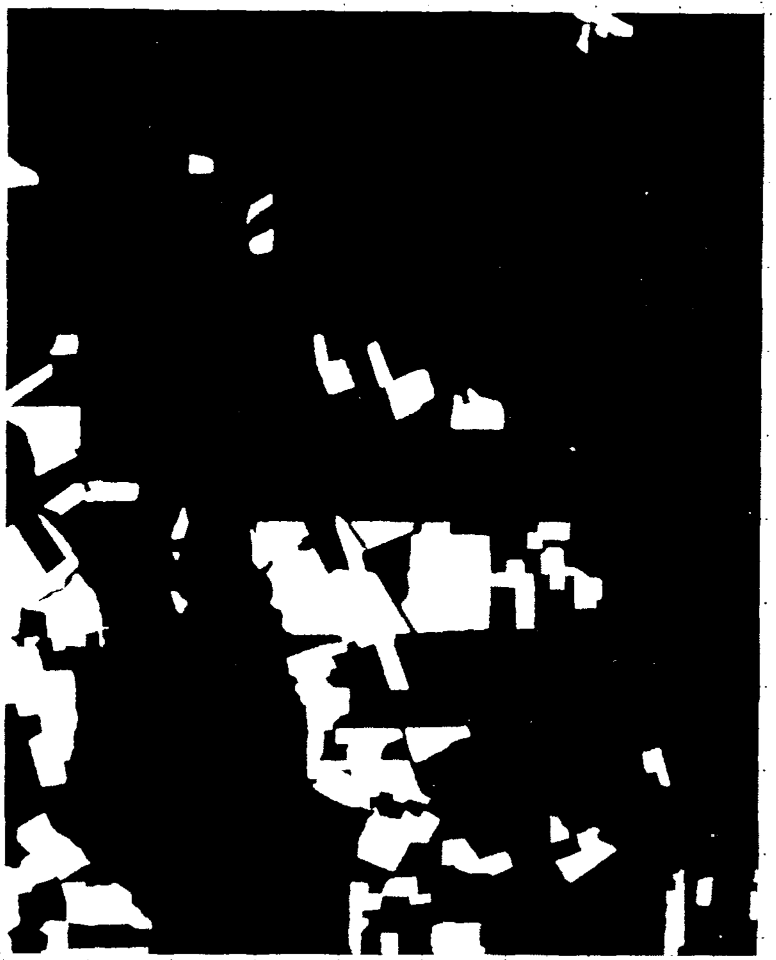

Figure A-7. Result of Query: FLD=BELO OR LU<>AVV

Figure A-8. Result of Query: LU<>AVV AND LU<>ACP

Figure A-9. Result of Query: LU=ACC OR LU=ACP

Figure A-10. Result of Query: FLD=BELO OR (LU NE AVV AND ELEV.CODE=1)

Figure A-11. Result of Query:
(FLD=ABOV)*ELEV.CODE*20

Figure A-12. Result of Query: FLD=BELO OR EL=500

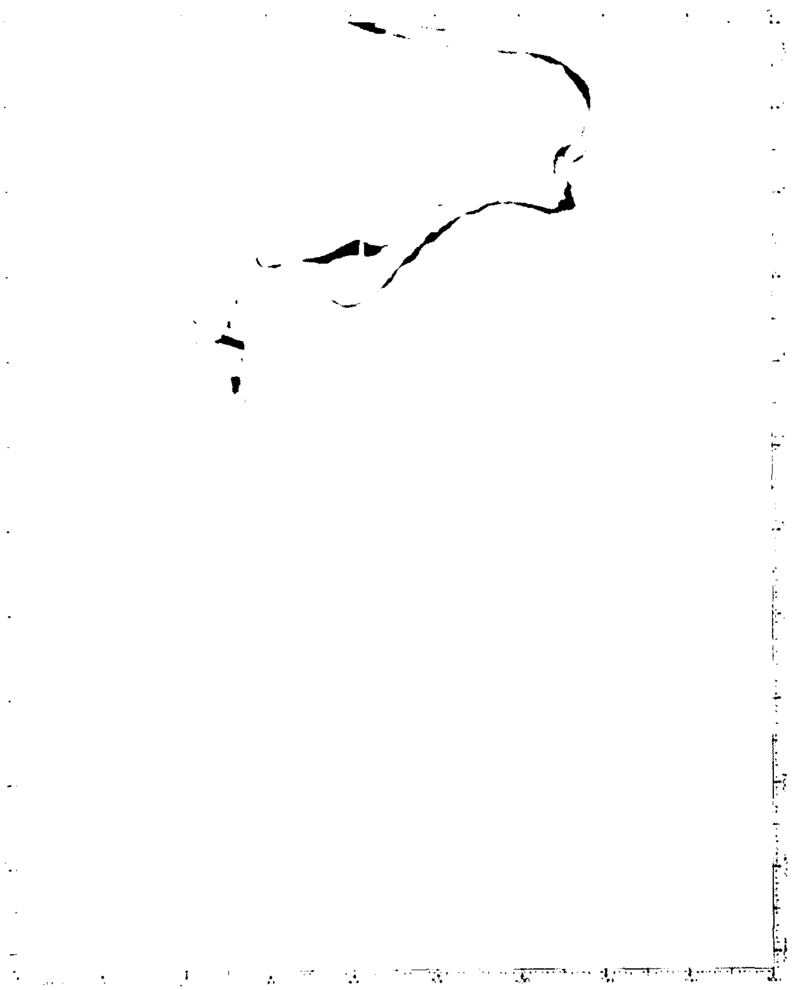

Figure A-13. Result of Query:
FLD=BELO AND ELEV.CODE GE 1

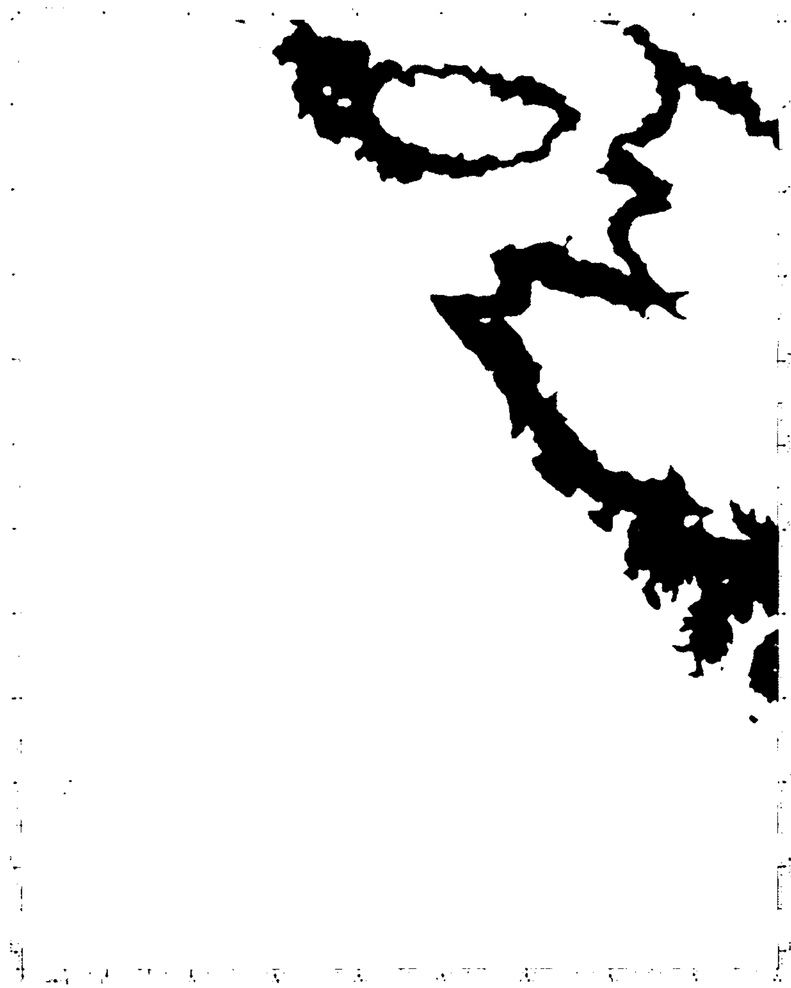

Figure A-14. Result of Query:
ELEV.CODE GE 3 AND ELEV.CODE LE 4

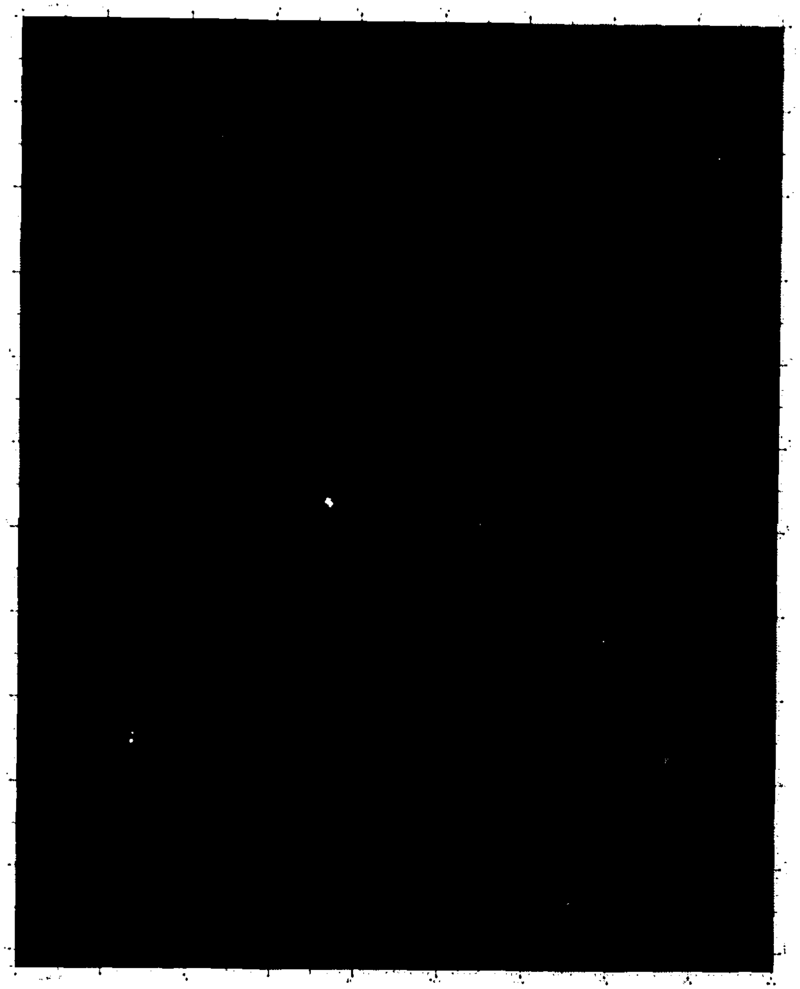

Figure A-15. Result of Query: LUREV<>0

Figure A-16. Result of Query:
FLD=BELO AND ELEV.CODE<=1

Figure A-17. Result of Query: ELEV.CODE=3 (Elevation zones between 300 and 400 feet)

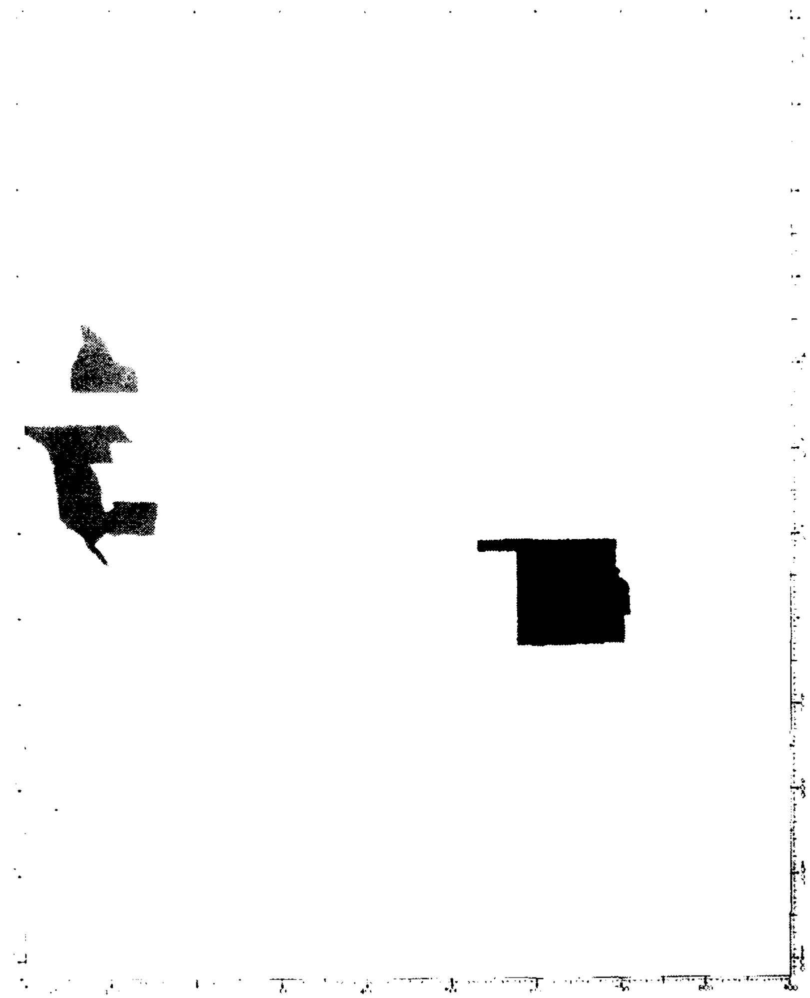

Figure A-18. Result of Query: LUREV>1 (Land areas affected by revision)

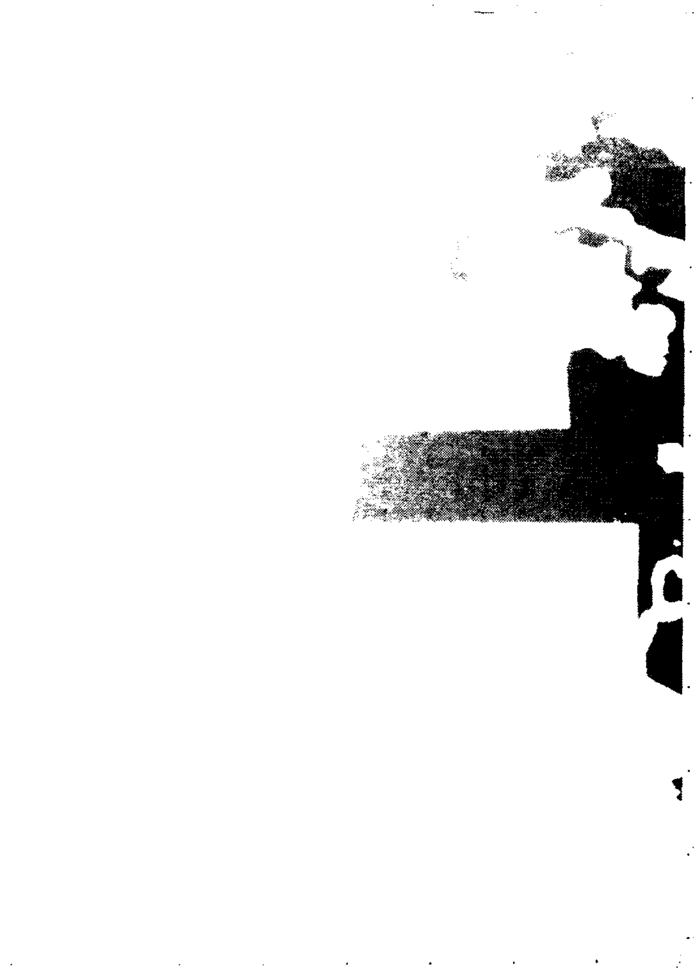

Figure A-19. Result of Query: LU=R

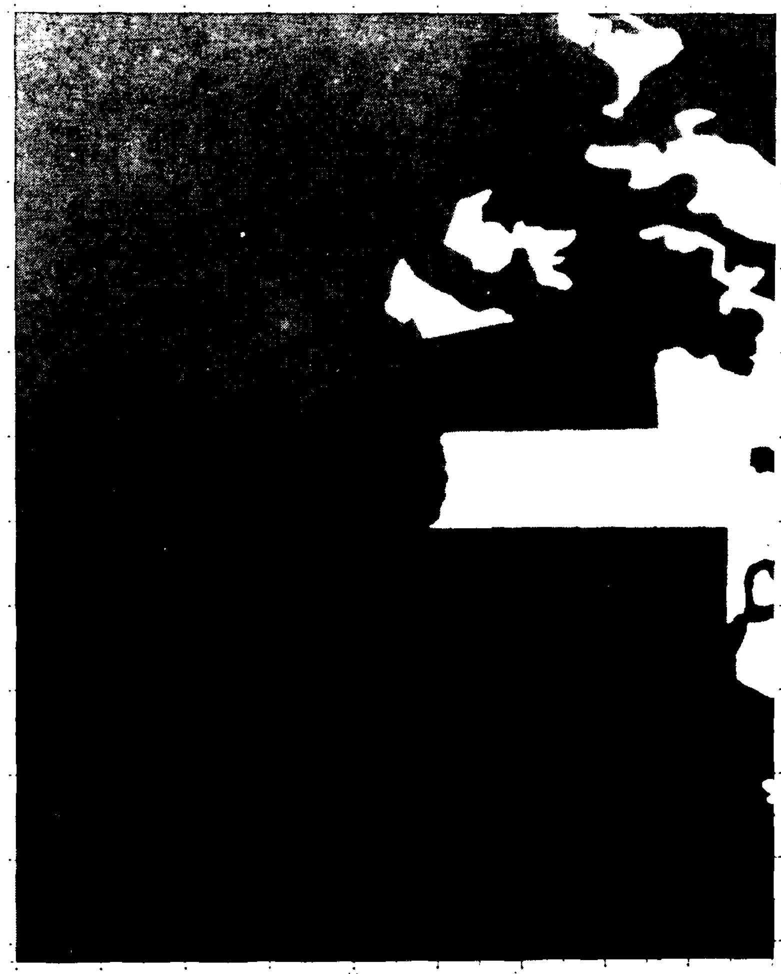

Figure A-20. Result of Query: LU<>R

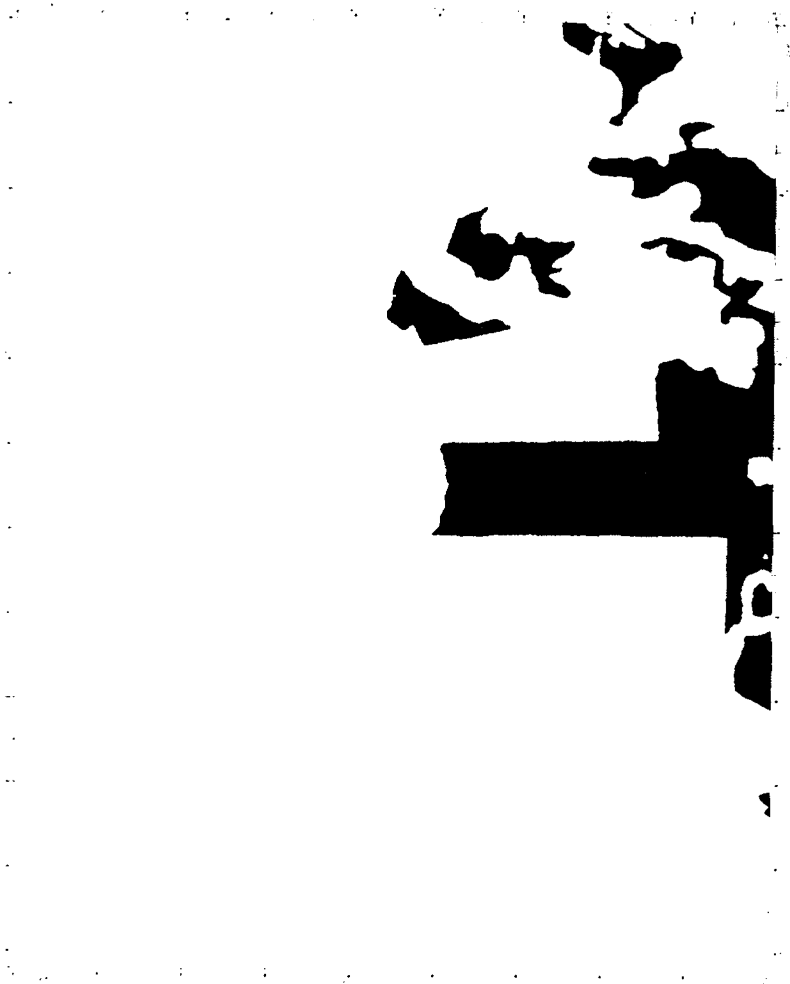

Figure A-21. Result of Query:
LU=R AND ELEV.CODE>=1

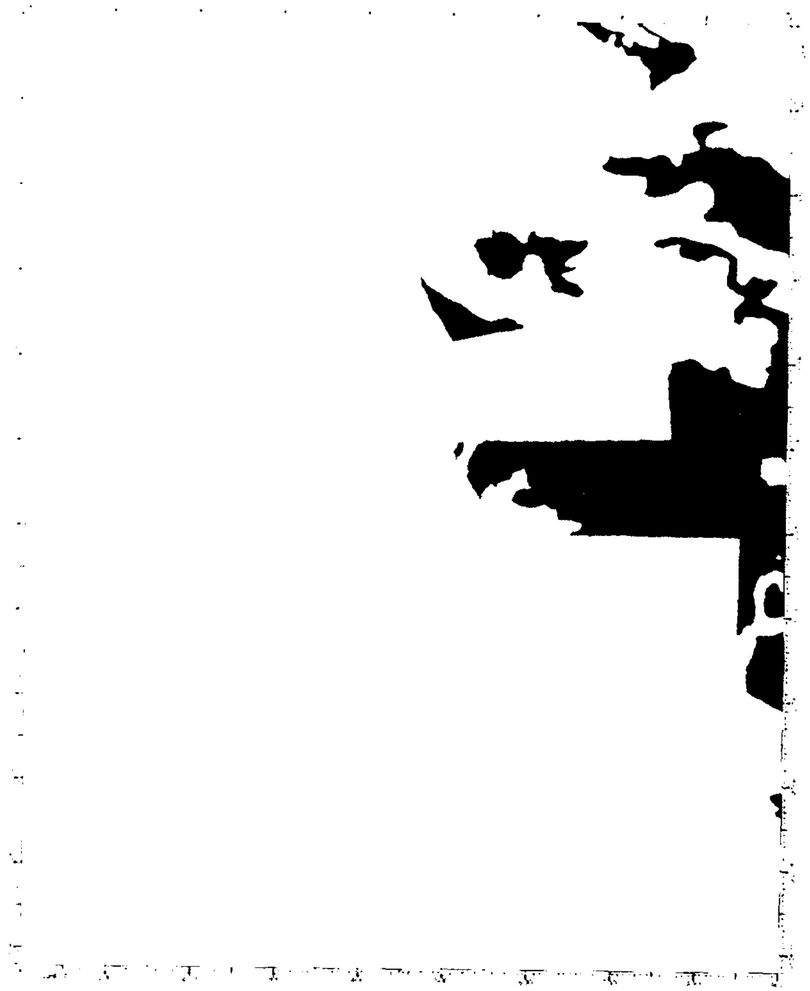

Figure A-22. Result of Query:
LU=R AND ELEV.CODE>=2

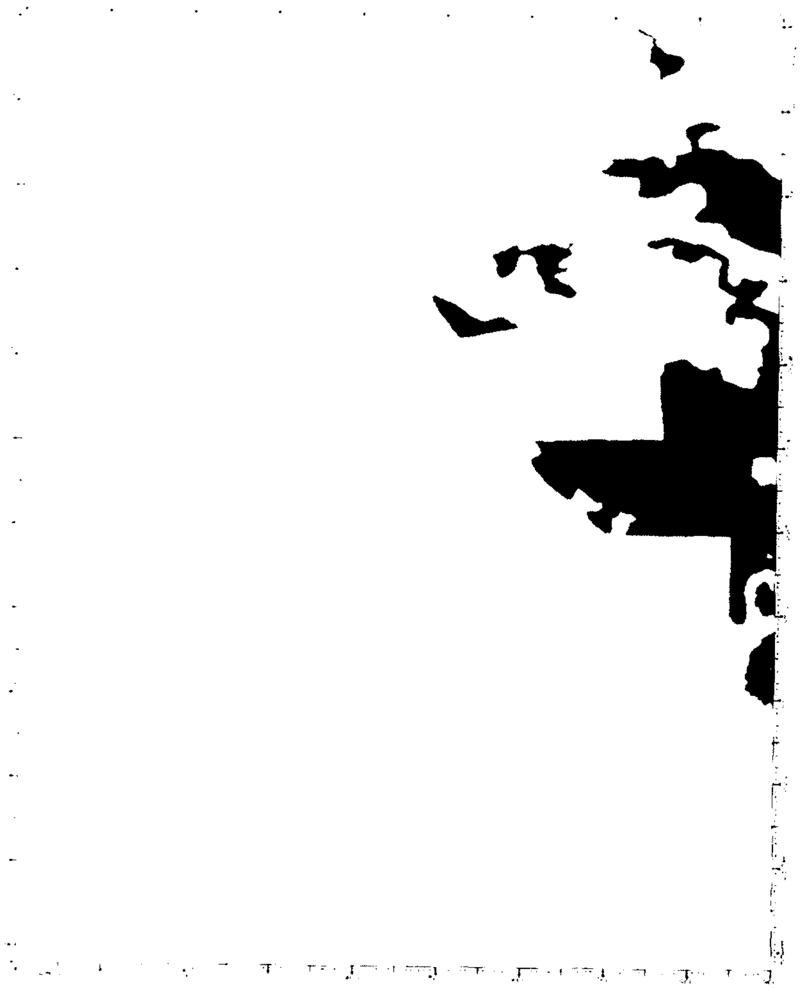

Figure A-23. Result of Query:
LU=R AND ELEV.CODE>=3

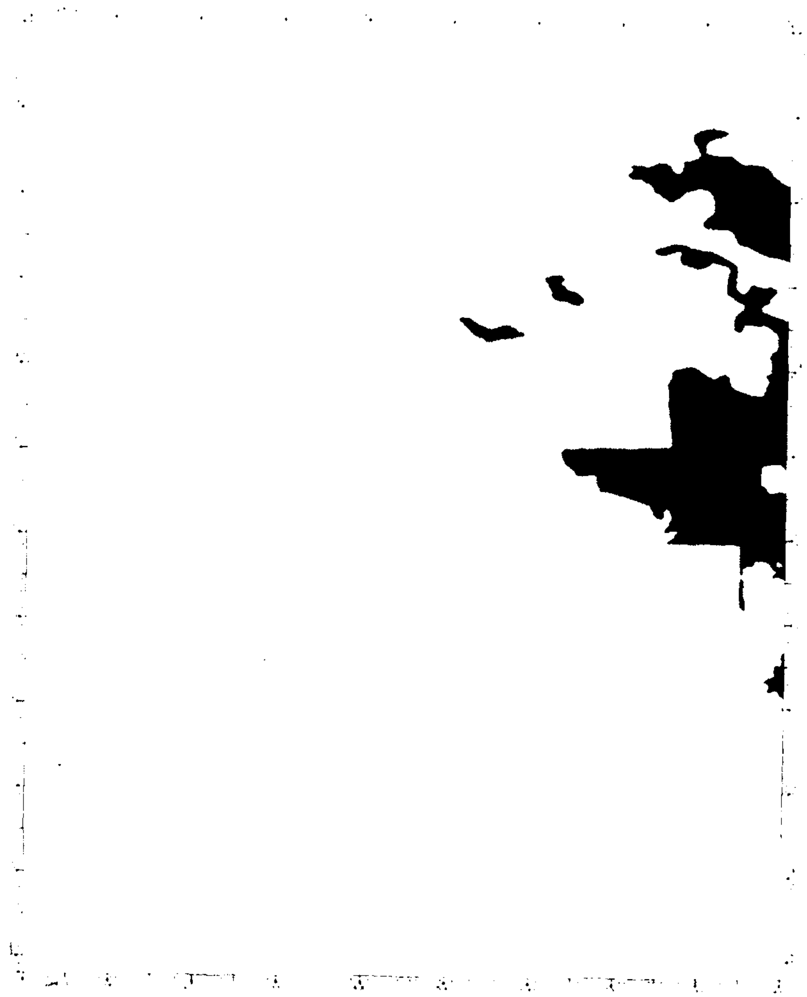

Figure A-24. Result of Query:
LU=R AND ELEV.CODE>=4

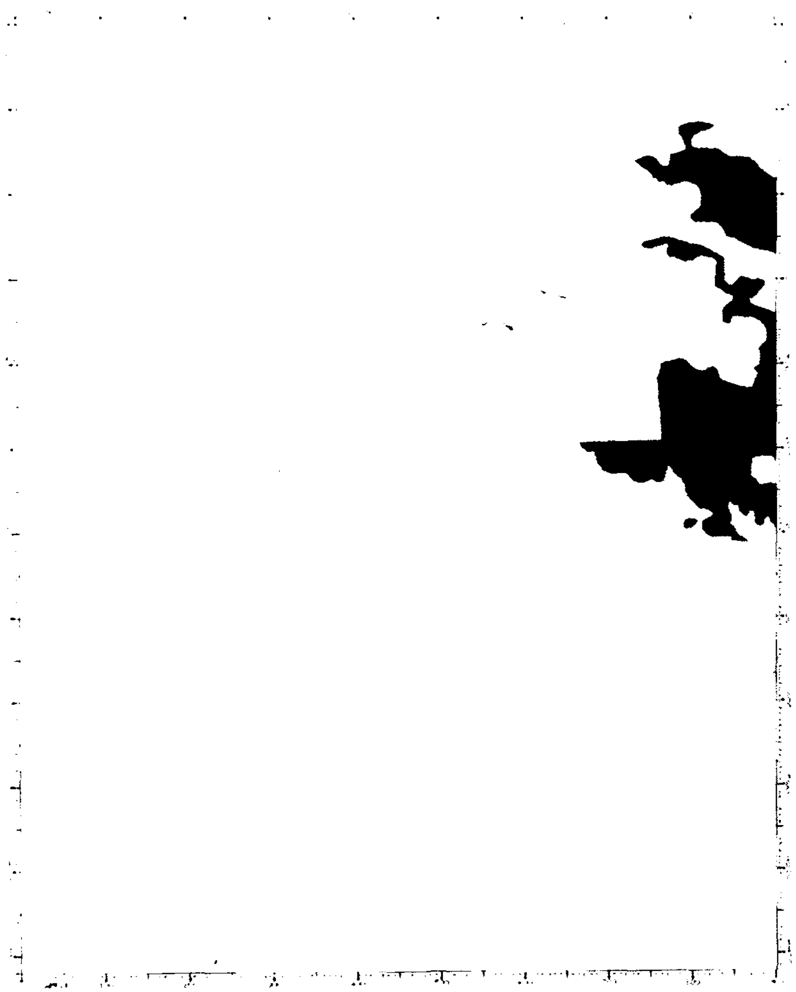

Figure A-25. Result of Query:
LU=R AND ELEV.CODE>=5

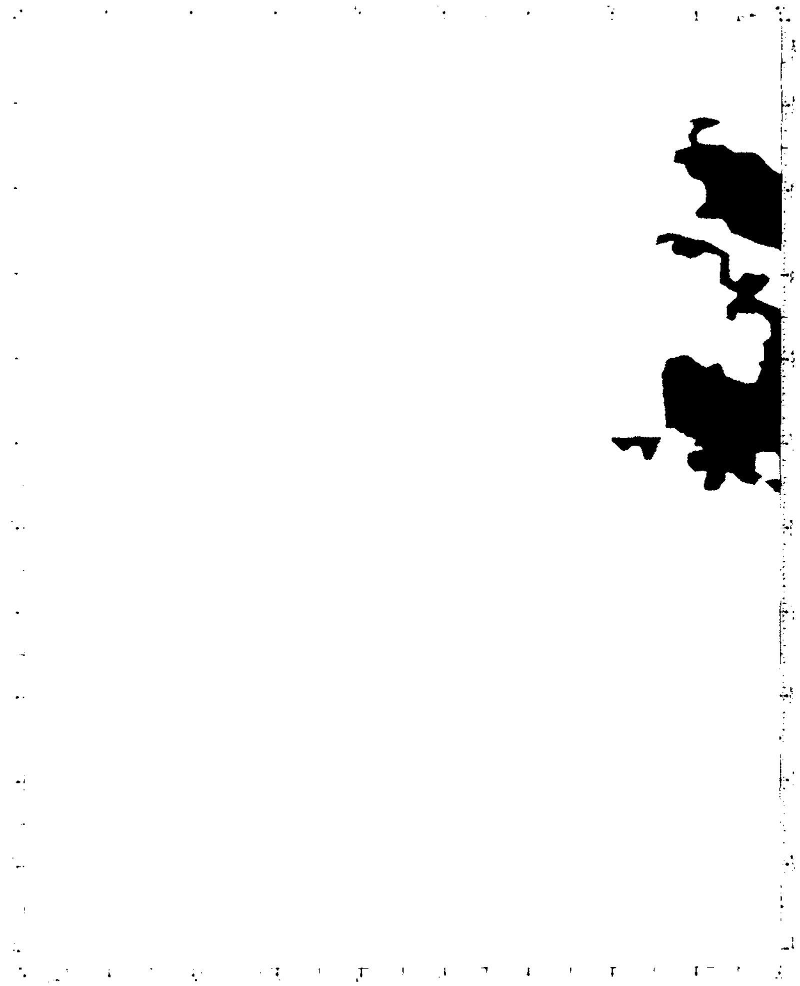

Figure A-26. Result of Query:
LU=R AND ELEV.CODE>=6

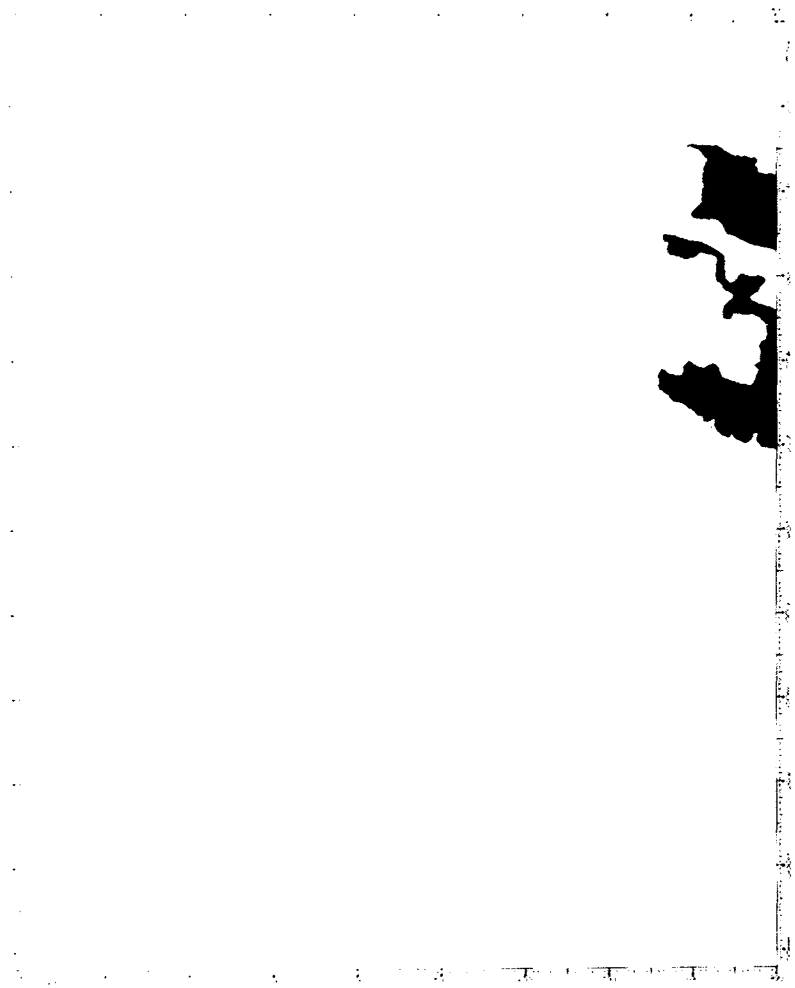

Figure A-27. Result of Query:
LU=R AND ELEV.CODE>=7

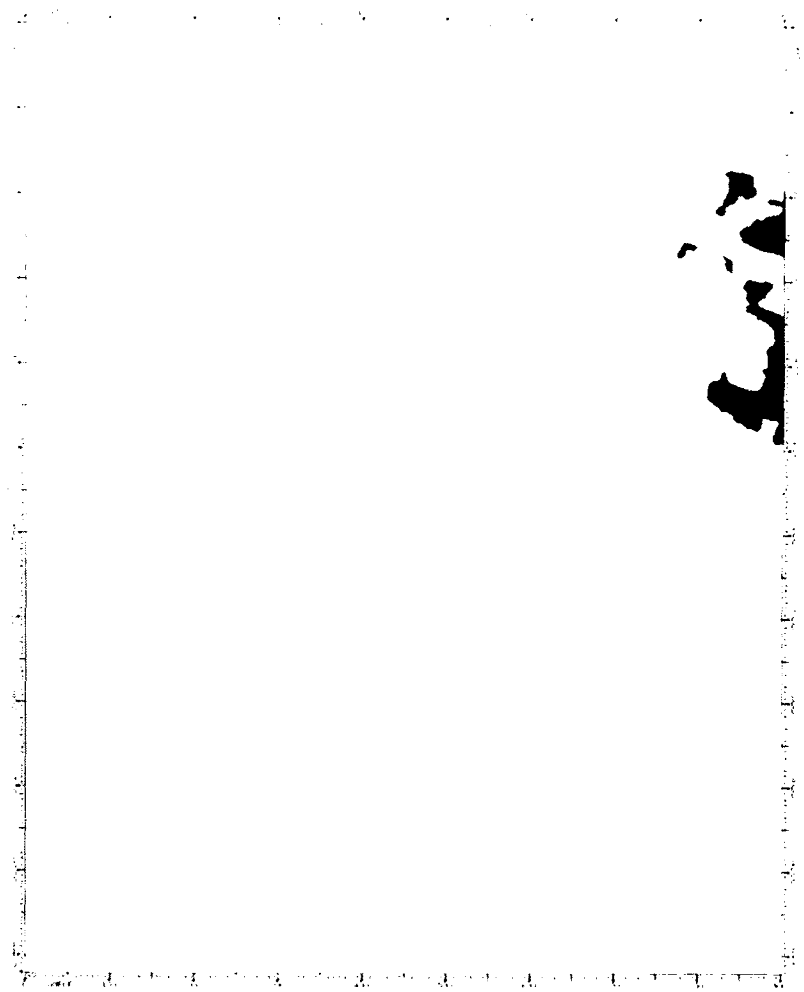

Figure A-28. Result of Query:
LU=R AND ELEV.CODE>=8

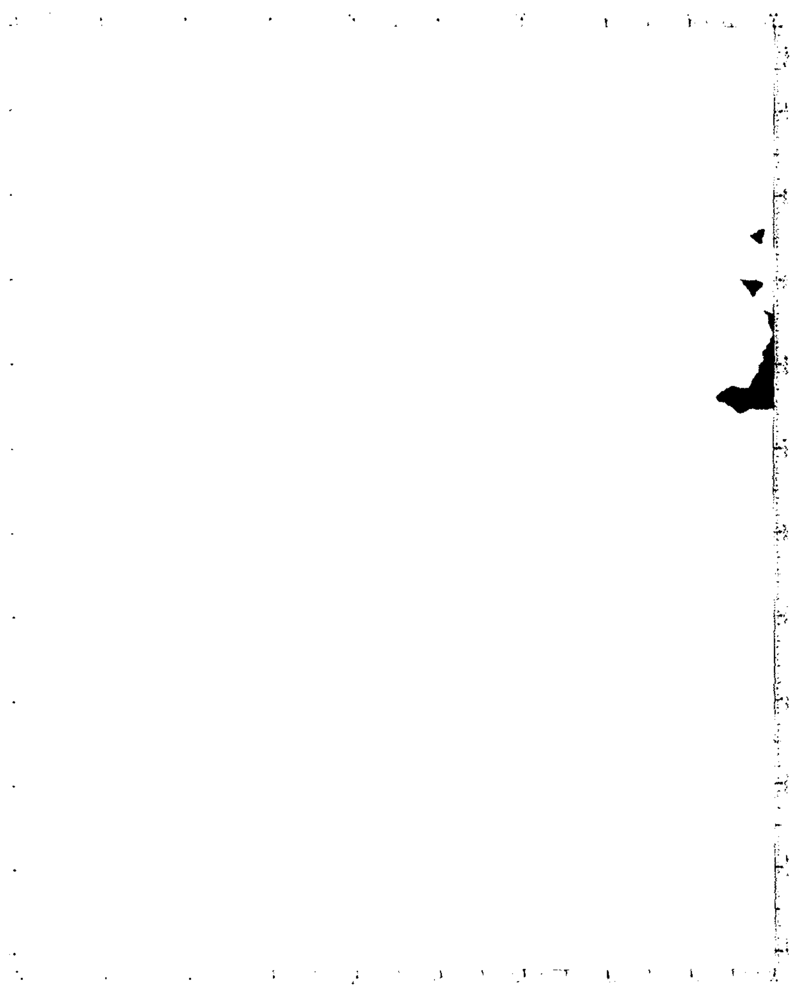

Figure A-29. Result of Query:
LU=R AND ELEV.CODE>=9

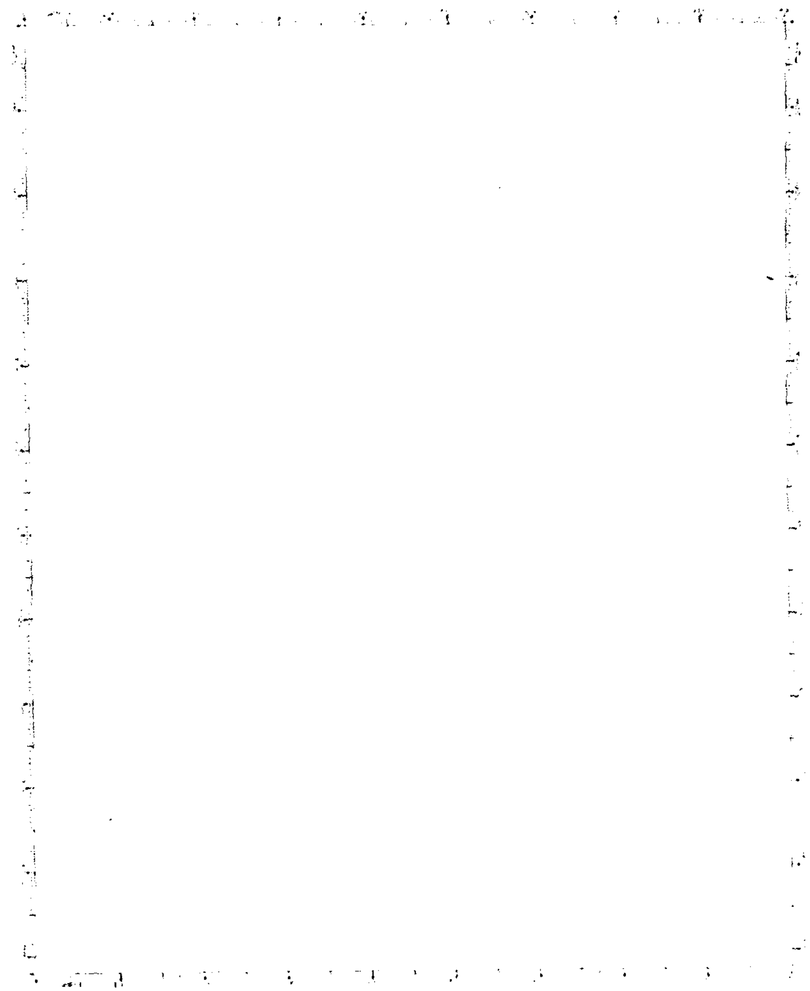

Figure A-30. Result of Query:
LU=R AND ELEV.CODE>=10

Table A-1. CPU Timings for Selected Queries (1 of 2)

Fig. No.	Expression	Pixels Alarmed	Acres	CPU Time*
A-1	LU=ACP AND FLD=BELO	886	8.14	3.14
A-2	LU=ACP AND FLD=ABOV	160,565	1,474.43	3.13
A-3	LU=ACP AND ELEV.CODE GE 3	35,955	330.17	3.16
A-4	LU=ACP AND (ELEV.CODE≥3 AND ELEV.CODE ≤5)	25,790	236.89	4.03
A-5	LU=ACP AND (ELEV.CODE≤2 OR ELEV.CODE>5)	135,661	1,245.74	4.01
A-6	LU=ACP AND ELEV.CODE<>5	155,918	1,431.75	3.14
A-7	FLD=BELO OR LU<>AVV	897,137	8,238.17	3.13
A-8	LU<>AVV AND LU<>ACP	665,116	6,107.58	3.08
A-9	LU=ACC OR LU=ACP (LU=ACC; ACP)	200,401	1,840.23	3.04
A-10	FLD=BELO OR (LU<>AVV AND ELEV.CODE=1)	465,238	4,272.16	4.08
A-11	(FLD=ABOV)*ELEV.CODE*20	637,931	5,857.95	3.06
A-12	FLD=BELO OR ELEV.CODE=500	218,373	2,005.26	3.03
A-13	FLD=BELO AND ELEV.CODE=1	8,431	77.42	3.09
4-2	LU=ACC	38,950	357.67	2.27
A-14	ELEV.CODE GE 3 AND ELEV.CODE LE 4	95,455	876.54	3.01
A-15	LUREV<>0	1,008,000	9,256.20	2.28
A-16	FLD=BELO AND ELEV.CODE LE 1	184,156	1,691.06	3.04
A-17	ELEV.CODE=3	54,622	501.58	2.28
A-18	LUREV>1	32,766	300.88	2.25
4-3	FLD=BELO AND ELEV.CODE<1	175,725	1,613.64	3.05
A-19	LU=R	100,411	922.05	2.26
A-20	LU<>R	907,589	8,334.15	2.29

*CPU Minutes

Table A-1. CPU Timings for Selected Queries (2 of 2)

Fig. No.	Expression		Pixels Alarmed	Acres	CPU Time*
	QUERY SERIES, SEQUENCED ON ELEVATION				
A-21	LU=R AND ELEV.CODE≥1		100,154	919.69	3.12
A-22	LU=R AND ELEV.CODE≥2		86,332	792.76	3.11
A-23	LU=R AND ELEV.CODE≥3		70,197	644.60	3.12
A-24	LU=R AND ELEV.CODE≥4		54,986	504.92	3.10
A-25	LU=R AND ELEV.CODE≥5		42,430	389.62	3.15
A-26	LU=R AND ELEV.CODE≥6		32,094	294.71	3.17
A-27	LU=R AND ELEV.CODE≥7		21,836	200.51	3.16
A-28	LU=R AND ELEV.CODE≥8		10,373	95.25	3.16
A-29	LU=R AND ELEV.CODE≥9		3,232	29.68	3.16
A-30	LU=R AND ELEV.CODE≥10		37	0.34	3.15
	COMPOSITE QUERIES				
4-2	LU=ACC	QUERY 1	38,950	357.67	
4-3	FLD=BELO AND CODE<1	QUERY 2	175,725	1,613.64	7.04
4-4	QUERY 1 AND QUERY 2		9,205	84.53	

*CPU Minutes

APPENDIX B

DETAILED DATA PLANE DESCRIPTIONS

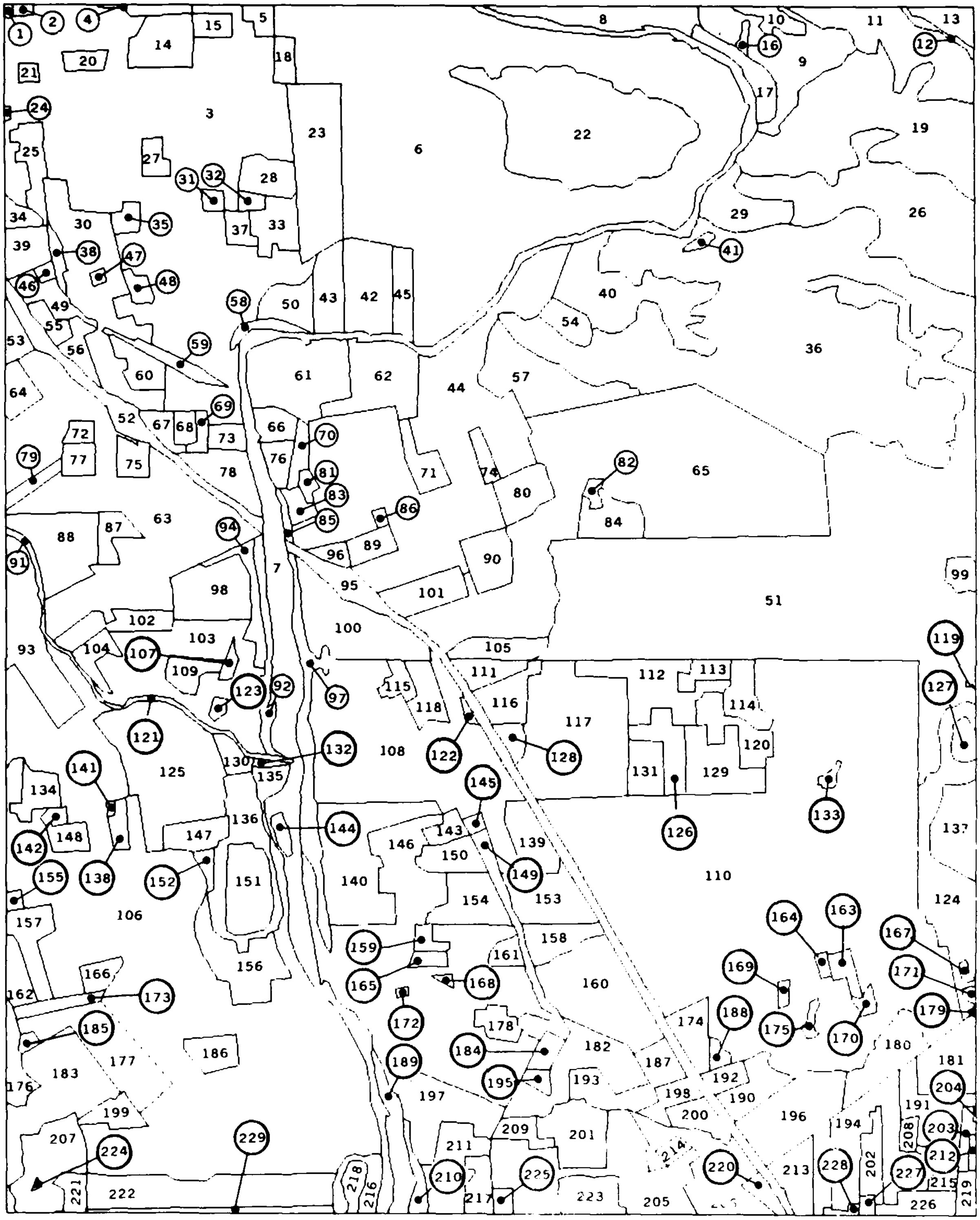

Figure B-1. Numerical Identification Codes Assigned to Geographic Regions Comprising the Land Use Data Plane

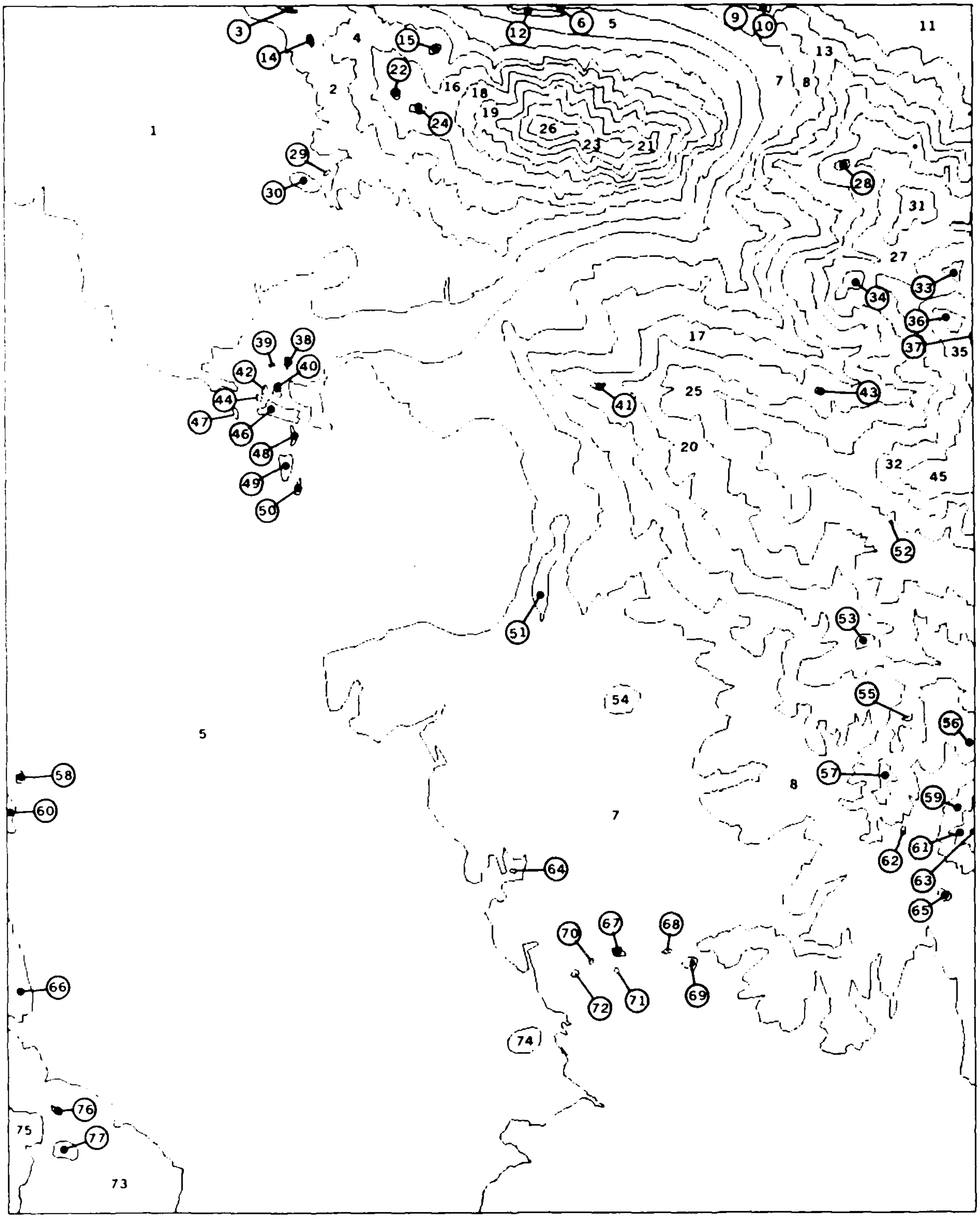

Figure B-2. Numerical Identification Codes Assigned to Regions Comprising the Contour Data Plane

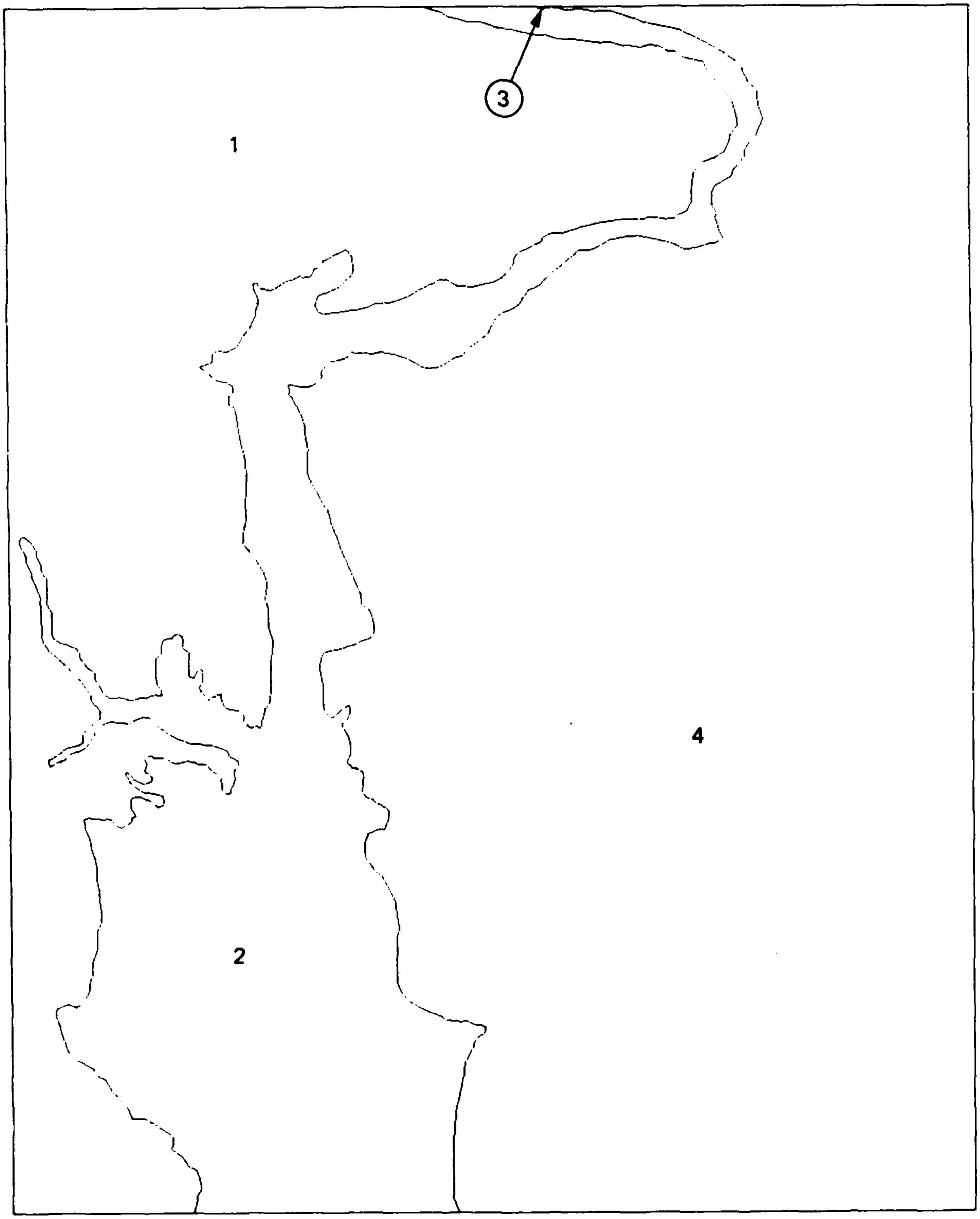

Figure B-3. Numerical Identification Codes Assigned to Regions Comprising the Floodplain Data Plane

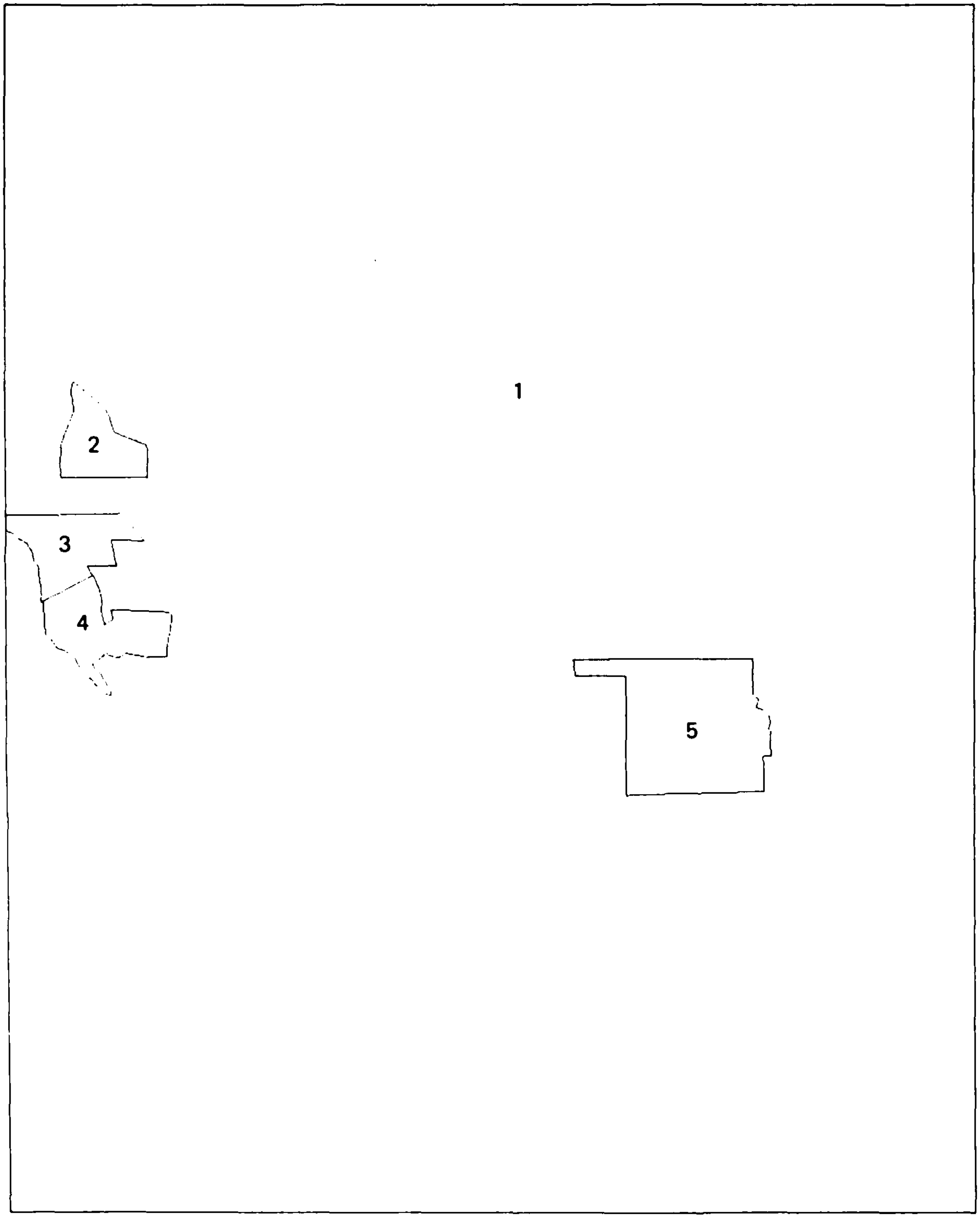

Figure B-4. Numerical Identification Codes Assigned to Regions Comprising the Land Use Revision Data Plane

Table B-1. Numerical Keys Assigned to Land Use and Land Use Revision Codes

Numerical Key	Label Code
1	ACC
2	ACP
3	AR
4	AVF
5	AVV
6	BBR
7	BEQ
8	BES
9	BT
10	FO
11	LR
12	R
13	UCB
14	UCC
15	UCR
16	UCW
17	UES
18	UIL
19	UIS
20	UIW
21	UOC
22	UOG
23	UOO
24	UOP
25	UOV
26	URH
27	URS
28	UUS
29	UUT
30	VV
31	WO
32	WS
33	WWP

Table B-2. Numerical Keys Assigned to 100-Foot Contour Elevation Zones

Numerical Key	Contour Zone (min - max)
0	0 - 100
1	101 - 200
2	201 - 300
3	301 - 400
4	401 - 500
5	501 - 600
6	601 - 700
7	701 - 800
8	801 - 900
9	901 - 1000
10	1001 - 1100

Table B-3. Numerical Keys Assigned to Floodplain Zones

Numerical Key	Floodplain Zone
0	Below
1	Above

Table B-4. Healdsburg Quadrangle Land Use Data Plane (1 of 6)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

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LAND USE DATA PLANE

- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
1	UIS	109	1.00	0.00156
2	UCP	209	1.92	0.00300
3	URS	55730	511.75	0.79961
4	BT	700	6.43	0.01004
5	UCV	703	6.46	0.01009
6	URS	64012	587.80	0.91844
7	WS	19689	180.80	0.28250
8	FO	3399	31.21	0.04877
9	R	6191	56.85	0.08883
10	AVV	952	8.74	0.01366
11	AVF	6659	61.15	0.09554
12	WS	443	4.07	0.00636
13	AVF	1302	11.96	0.01868
14	UCC	2667	24.49	0.03827
15	UCB	799	7.34	0.01146
16	AVV	233	2.14	0.00334
17	URS	1800	16.53	0.02583
18	UCV	839	7.70	0.01204
19	FO	16436	150.93	0.23582
20	AVF	719	6.60	0.01032
21	UCR	317	2.91	0.00455
22	FO	16122	148.04	0.23132
23	UCG	6911	63.46	0.09916
24	UIS	82	0.75	0.00118
25	UIS	1759	16.15	0.02524
26	R	13821	126.91	0.19830
27	UCC	776	7.13	0.01113
28	UCC	1759	16.15	0.02524
29	URS	2934	26.94	0.04210
30	UCR	8351	76.68	0.11982
31	UCC	404	3.71	0.00580
32	AVV	413	3.79	0.00593
33	AVF	1984	18.22	0.02847
34	AVV	684	6.28	0.00981
35	UCC	659	6.05	0.00946
36	FO	52040	477.87	0.74667
37	UCC	784	7.20	0.01125
38	UCW	551	5.06	0.00791
39	UCO	1688	15.50	0.02422
40	R	7188	66.01	0.10313
41	AVF	257	2.36	0.00369
42	AVF	3864	35.48	0.05544

Table B-4. Healdsburg Quadrangle Land Use Data Plane (2 of 6)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

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LAND USE DATA PLANE

- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
43	AVV	2215	20.34	0.03176
44	AVF	30287	278.12	0.43456
45	BT	1561	14.33	0.02240
46	UCW	260	2.39	0.00373
47	UCP	171	1.57	0.00245
48	UCB	594	5.45	0.00852
49	URS	1496	13.74	0.02146
50	AVF	1796	16.49	0.02577
51	R	63522	583.30	0.91141
52	UUT	3773	34.65	0.05413
53	URS	921	8.46	0.01321
54	AR	1273	11.69	0.01826
55	AVF	811	7.45	0.01164
56	UCW	1066	9.79	0.01529
57	R	5509	50.59	0.07904
58	LR	660	6.06	0.00947
59	UUT	1066	9.79	0.01529
60	UIL	1465	13.45	0.02102
61	UES	6026	55.33	0.08646
62	URS	4472	41.07	0.06416
63	AVF	23564	216.38	0.33810
64	ACC	1222	11.22	0.01753
65	ACP	37091	340.60	0.53218
66	UCP	1124	10.32	0.01613
67	UCC	864	7.93	0.01240
68	UCR	621	5.70	0.00891
69	UIS	502	4.61	0.00720
70	UIS	784	7.20	0.01125
71	AVV	1460	13.41	0.02095
72	AVV	526	4.83	0.00755
73	URH	821	7.54	0.01178
74	AVV	703	6.46	0.01009
75	UIS	1006	9.24	0.01443
76	BES	975	8.95	0.01399
77	ACC	940	8.63	0.01349
78	URS	2428	22.30	0.03484
79	AVV	704	6.46	0.01010
80	AVV	2055	18.87	0.02949
81	URS	373	3.43	0.00535
82	UIW	348	3.20	0.00499
83	VV	679	6.24	0.00974
84	AVV	2079	19.09	0.02983

Table B-4. Healdsburg Quadrangle Land Use Data Plane (3 of 6)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240.000 1 PIXEL = 400 SQ FT

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- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
85	LR	333	3.06	0.00478
86	ACC	197	1.81	0.00283
87	ACC	1188	10.91	0.01705
88	AVV	4334	39.80	0.06218
89	UIL	1112	10.21	0.01595
90	ACC	2144	19.69	0.03076
91	WS	817	7.50	0.01172
92	LR	1767	16.23	0.02535
93	AVF	5465	50.18	0.07841
94	UFS	1468	13.48	0.02106
95	UUT	7520	69.05	0.10790
96	UCC	575	5.28	0.00825
97	LR	4077	37.44	0.05850
98	ACC	3687	33.86	0.05290
99	AP	840	7.71	0.01205
100	AVF	5777	53.05	0.08289
101	ACC	2190	20.11	0.03142
102	AVV	2048	18.81	0.02938
103	AVF	9887	90.79	0.14186
104	ACP	1126	10.34	0.01616
105	ACC	1689	15.51	0.02423
106	AVV	69718	640.20	1.00031
107	AVV	350	3.21	0.00502
108	AVV	20096	184.54	0.28834
109	URS	1200	11.02	0.01722
110	ACP	85992	789.64	1.23381
111	AVV	1282	11.77	0.01839
112	AVF	4308	39.56	0.06181
113	AVV	954	8.76	0.01369
114	ACP	1712	15.72	0.02456
115	UIW	829	7.61	0.01189
116	AVF	1965	18.04	0.02819
117	AVV	11109	102.01	0.15939
118	ACC	1565	14.37	0.02245
119	WWP	25	0.23	0.00036
120	AVV	2266	20.81	0.03251
121	WS	830	7.62	0.01191
122	AVF	180	1.65	0.00258
123	AVV	259	2.38	0.00372
124	BT	7319	67.21	0.10501
125	AVF	10037	92.17	0.14401
126	AVV	2100	19.28	0.03013

Table B-4. Healdsburg Quadrangle Land Use Data Plane (4 of 6)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240.000 1 PIXEL = 400 SQ FT

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- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
127	R	823	7.56	0.01181
128	URS	708	6.50	0.01016
129	ACP	3443	31.62	0.04940
130	AVV	815	7.48	0.01169
131	URS	1687	15.49	0.02421
132	BBR	183	1.68	0.00263
133	WWP	270	2.48	0.00387
134	AVF	1437	13.20	0.02062
135	AVV	918	8.43	0.01317
136	UES	4191	38.48	0.06013
137	R	3138	28.82	0.04502
138	AVF	691	6.35	0.00991
139	ACP	2187	20.08	0.03138
140	ACC	7185	65.98	0.10309
141	ACC	100	0.92	0.00143
142	URS	337	3.09	0.00484
143	AR	806	7.40	0.01156
144	BBR	473	4.34	0.00679
145	UPH	283	2.60	0.00406
146	AVV	27535	252.85	0.39507
147	UUS	1537	14.11	0.02205
148	AVF	930	8.54	0.01334
149	UFS	2396	22.00	0.03438
150	UIS	1625	14.92	0.02332
151	WO	3269	30.02	0.04690
152	AVF	459	4.21	0.00659
153	ACC	3327	30.55	0.04774
154	AR	2681	24.62	0.03847
155	AVF	276	2.53	0.00396
156	AVF	3931	36.10	0.05640
157	ACP	2132	19.58	0.03059
158	AVV	1853	17.02	0.02659
159	ACP	555	5.10	0.00796
160	URS	6963	63.94	0.09990
161	URS	693	6.36	0.00994
162	UPS	1242	11.40	0.01782
163	AVV	761	6.99	0.01092
164	AVF	254	2.33	0.00364
165	AVF	480	4.41	0.00689
166	ACP	852	7.82	0.01222
167	WWP	172	1.58	0.00247
168	FO	135	1.24	0.00194

Table B-4. Healdsburg Quadrangle Land Use Data Plane (5 of 6)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

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- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
169	AVF	243	2.23	0.00349
170	WWP	377	3.46	0.00541
171	R	164	1.51	0.00235
172	UUS	91	0.84	0.00131
173	ACC	909	8.35	0.01304
174	ACC	1733	15.91	0.02487
175	WWP	321	2.95	0.00461
176	ACP	1496	13.74	0.02146
177	AVF	5220	47.93	0.07490
178	UCC	1027	9.43	0.01474
179	R	54	0.50	0.00077
180	ACC	2953	27.12	0.04237
181	BT	3055	28.05	0.04383
182	AVF	4630	42.52	0.06643
183	AVV	6559	60.23	0.09411
184	AVV	732	6.72	0.01050
185	URS	265	2.43	0.00380
186	AVF	1371	12.59	0.01967
187	ACC	1308	12.01	0.01877
188	AVV	419	3.85	0.00601
189	BBF	2295	21.07	0.03293
190	AVV	1967	18.06	0.02822
191	ACP	2974	27.31	0.04267
192	AVF	855	7.85	0.01227
193	AVV	1977	18.15	0.02837
194	ACP	6018	55.26	0.08635
195	URS	448	4.11	0.00643
196	AVF	6268	57.56	0.08993
197	ACC	4193	38.50	0.06016
198	URS	1147	10.53	0.01646
199	URS	1208	11.09	0.01733
200	ACC	1357	12.46	0.01947
201	URS	3186	29.26	0.04571
202	AVV	1468	13.48	0.02106
203	AVF	618	5.67	0.00887
204	AVV	39	0.36	0.00056
205	ACP	8996	82.61	0.12907
206	URS	5207	47.81	0.07471
207	ACP	4135	37.97	0.05933
208	AVV	509	4.67	0.00730
209	AVV	1000	9.18	0.01435
210	LP	827	7.59	0.01187

Table B-4. Healdsburg Quadrangle Land Use Data Plane (6 of 6)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

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POLYGON		AREAL COVERAGE		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
211	AVV	3263	29.96	0.04682
212	AVV	230	2.11	0.00330
213	ACP	1955	17.95	0.02805
214	UIS	472	4.33	0.00677
215	ACC	1143	10.50	0.01640
216	BEQ	1441	13.23	0.02068
217	AR	1256	11.53	0.01802
218	WO	798	7.33	0.01145
219	ACP	782	7.18	0.01122
220	BT	671	6.16	0.00963
221	AVV	888	8.15	0.01274
222	AVF	6782	62.28	0.09731
223	AVV	2025	18.59	0.02905
224	WWP	54	0.50	0.00077
225	AVV	454	4.17	0.00651
226	URS	1501	13.78	0.02154
227	AVV	278	2.55	0.00399
228	URS	256	2.35	0.00367
229	AVV	1310	12.03	0.01880

Table B-5. Healdsburg Quadrangle Countour Data Plane (1 of 2)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY REPORT
CONTOUR DATA PLANE

- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
1	150	101144	928.77	1.45120
2	250	21204	194.71	0.30423
3	350	64	0.59	0.00092
4	350	14100	129.48	0.20231
5	50	361599	3320.43	5.18811
6	150	19	0.17	0.00027
7	150	212938	1955.33	3.05516
8	250	77971	715.98	1.11872
9	350	8	0.07	0.00011
10	350	124	1.14	0.00178
11	150	5778	53.06	0.08290
12	150	271	2.49	0.00389
13	350	38578	354.25	0.55352
14	350	50	0.46	0.00072
15	450	74	0.68	0.00106
16	450	10431	95.78	0.14966
17	450	29276	268.83	0.42005
18	550	4944	45.40	0.07094
19	650	4325	39.72	0.06205
20	550	28852	264.94	0.41397
21	750	2895	26.58	0.04154
22	550	70	0.64	0.00100
23	850	1864	17.12	0.02674
24	550	103	0.95	0.00148
25	650	28716	263.69	0.41202
26	950	691	6.35	0.00991
27	750	20577	188.95	0.29524
28	750	91	0.84	0.00131
29	250	17	0.16	0.00024
30	250	356	3.27	0.00511
31	850	1277	11.73	0.01832
32	850	8268	75.92	0.11863
33	950	209	1.92	0.00300
34	650	392	3.60	0.00562
35	950	2076	19.06	0.02979
36	1050	375	3.44	0.00538
37	850	20	0.18	0.00029
38	150	46	0.42	0.00066
39	150	12	0.11	0.00017
40	150	71	0.65	0.00102
41	550	55	0.51	0.00079
42	150	21	0.19	0.00030

Table B-5. Healdsburg Quadrangle Countour Data Plane (2 of 2)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY REPORT
CONTOUR DATA PLANE

- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
43	650	28	0.26	0.00040
44	150	21	0.19	0.00030
45	950	2693	24.73	0.03864
46	150	397	3.65	0.00570
47	150	35	0.32	0.00050
48	150	53	0.49	0.00076
49	150	231	2.12	0.00331
50	150	48	0.44	0.00069
51	250	1166	10.71	0.01673
52	750	9	0.08	0.00013
53	550	169	1.55	0.00242
54	250	675	6.20	0.00968
55	550	28	0.26	0.00040
56	450	13	0.12	0.00019
57	450	428	3.93	0.00614
58	150	63	0.58	0.00090
59	350	1593	14.63	0.02286
60	150	225	2.07	0.00323
61	450	568	5.22	0.00815
62	350	33	0.30	0.00047
63	550	12	0.11	0.00017
64	150	15	0.14	0.00022
65	350	94	0.86	0.00135
66	150	1458	13.39	0.02092
67	250	78	0.72	0.00112
68	250	24	0.22	0.00034
69	250	124	1.14	0.00178
70	250	12	0.11	0.00017
71	250	15	0.14	0.00022
72	250	35	0.32	0.00050
73	150	14784	135.76	0.21212
74	150	567	5.21	0.00814
75	250	1999	18.36	0.02868
76	250	38	0.35	0.00055
77	250	317	2.91	0.00455

Table B-6. Healdsburg Quadrangle Floodplain Data Plane

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY REPORT
FLOODPLAIN DATA PLANE

- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
1	ABOV	286819	2633.75	4.11518
2	BELC	184201	1691.45	2.64284
3	ABOV	20	0.18	0.00029
4	ABOV	536960	4930.52	7.70410

Table B-7. Healdsburg Quadrangle Land Use Revision Data Plane

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY REPORT
LAND USE REVISION DATA PLANE

- POLYGON -		-- AREAL COVERAGE --		
NUMBER	LABEL	PIXELS	ACRES	SQ MILES
1		975334	8955.50	13.99371
2	UIS	4390	40.31	0.06299
3	ACC	5606	51.48	0.08043
4	AVV	6200	56.93	0.08896
5	UFS	16470	151.24	0.23631

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (1 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240.000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
1	UIS	150	ABOV		109	1.00	0.00156
2	UCR	150	ABOV		209	1.92	0.00300
3	URS	150	ABOV		52030	477.78	0.74652
4	BT	150	ABOV		700	6.43	0.01004
5	UOV	150	ABOV		385	3.54	0.00552
6	UOV	250	ABOV		318	2.92	0.00456
7	URS	250	ABOV		19199	176.30	0.27547
8	URS	350	ABOV		64	0.59	0.00092
9	URS	350	ABOV		13690	125.71	0.19642
10	URS	150	BELO		2154	19.78	0.03091
11	WS	50	BELO		19591	179.90	0.28109
12	FO	50	BELO		1601	14.70	0.02297
13	FO	150	ABOV		8	0.07	0.00011
14	FO	150	ABOV		11	0.10	0.00016
15	FO	150	ABOV		1311	12.04	0.01881
16	FO	250	ABOV		35	0.32	0.00050
17	R	250	ABOV		1992	18.29	0.02858
18	AVV	250	ABOV		401	3.68	0.00575
19	AVV	350	ABOV		8	0.07	0.00011
20	AVV	350	ABOV		124	1.14	0.00178
21	R	250	ABOV		39	0.36	0.00056
22	AVF	250	ABOV		476	4.37	0.00683
23	AVF	150	ABOV		3973	36.48	0.05700
24	WS	150	ABOV		443	4.07	0.00636
25	AVF	150	ABOV		1302	11.96	0.01868
26	URS	50	BELO		13	0.12	0.00019
27	FO	50	ABOV		12	0.11	0.00017
28	FO	150	BELO		271	2.49	0.00389
29	R	350	ABOV		1203	11.05	0.01726
30	AVF	350	ABOV		73	0.67	0.00105
31	R	150	ABOV		616	5.66	0.00884
32	AVV	350	ABOV		366	3.36	0.00525
33	UCC	150	ABOV		2667	24.49	0.03827
34	UCB	150	ABOV		799	7.34	0.01146
35	URS	150	ABOV		13805	126.77	0.19807
36	FO	50	ABOV		112	1.03	0.00161
37	AVV	250	ABOV		71	0.65	0.00102
38	R	250	ABOV		468	4.30	0.00671
39	URS	150	ABOV		113	1.04	0.00162
40	URS	150	ABOV		1180	10.84	0.01693
41	AVV	250	ABOV		53	0.49	0.00076
42	FO	50	BELO		38	0.35	0.00055
43	URS	50	BELO		464	4.26	0.00666

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (2 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES - LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	-- AREAL COVERAGE -- PIXELS	ACRES	SQ MILES
44	AVV	150	ABOV		162	1.49	0.00232
45	AVF	250	ABOV		313	2.87	0.00449
46	URS	50	BELO		85	0.78	0.00122
47	URS	50	ABOV		84	0.77	0.00121
48	R	150	ABOV		1827	16.78	0.02621
49	URS	350	ABOV		50	0.46	0.00072
50	UOV	150	ABOV		752	6.91	0.01079
51	UOV	250	ABOV		78	0.72	0.00112
52	FO	150	ABOV		9	0.08	0.00013
53	FO	250	ABOV		458	4.21	0.00657
54	FO	150	ABOV		8	0.07	0.00011
55	URS	450	ABOV		74	0.68	0.00106
56	URS	450	ABOV		6270	57.58	0.08996
57	URS	50	BELO		11	0.10	0.00016
58	AVF	250	ABOV		556	5.11	0.00798
59	AVF	150	ABOV		719	6.60	0.01032
60	URS	50	ABOV		29	0.27	0.00042
61	FO	350	ABOV		648	5.95	0.00930
62	UOV	250	ABOV		9	0.08	0.00013
63	URS	50	BELO		8	0.07	0.00011
64	URS	350	ABOV		204	1.87	0.00293
65	AVF	250	ABOV		768	7.05	0.01102
66	URS	50	BELO		299	2.75	0.00429
67	URS	50	BELO		57	0.52	0.00082
68	URS	50	ABOV		115	1.06	0.00165
69	R	450	ABOV		11	0.10	0.00016
70	FO	150	ABOV		18	0.17	0.00026
71	FO	250	ABOV		297	2.73	0.00426
72	FO	450	ABOV		3625	33.29	0.05201
73	URS	450	ABOV		26	0.24	0.00037
74	URS	450	ABOV		21	0.19	0.00030
75	UCR	150	ABOV		317	2.91	0.00455
76	FO	450	ABOV		2466	22.64	0.03538
77	FO	350	ABOV		76	0.70	0.00109
78	URS	450	ABOV		34	0.31	0.00049
79	FO	350	ABOV		1491	13.69	0.02139
80	URS	150	ABOV		150	1.38	0.00215
81	FO	350	ABOV		10	0.09	0.00014
82	URS	450	ABOV		51	0.47	0.00073
83	FO	550	ABOV		3555	32.64	0.05101
84	FO	350	ABOV		11	0.10	0.00016
85	AVF	350	ABOV		166	1.52	0.00238
86	FO	350	ABOV		1210	11.11	0.01736

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (3 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES - LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	-- AREAL COVERAGE -- PIXELS	ACRES	SQ MILES
87	URS	450	ABOV		10	0.09	0.00014
88	FO	350	ABOV		52	0.48	0.00075
89	URS	450	ABOV		39	0.36	0.00056
90	FO	250	ABOV		1431	13.14	0.02053
91	AVF	350	ABOV		334	3.07	0.00479
92	FO	650	ABOV		3528	32.40	0.05062
93	UOG	150	ABOV		4929	45.26	0.07072
94	UOG	250	ABOV		1338	12.29	0.01920
95	FO	550	ABOV		3031	27.83	0.04349
96	URS	550	ABOV		1389	12.75	0.01993
97	FO	750	ABOV		2833	26.01	0.04065
98	URS	550	ABOV		70	0.64	0.00100
99	URS	450	ABOV		56	0.51	0.00080
100	FO	150	ABOV		45	0.41	0.00065
101	FO	350	ABOV		15	0.14	0.00022
102	URS	450	ABOV		14	0.13	0.00020
103	FO	250	ABOV		595	5.46	0.00854
104	URS	450	ABOV		18	0.17	0.00026
105	URS	650	ABOV		797	7.32	0.01144
106	FO	850	ABOV		1864	17.12	0.02674
107	URS	50	BELO		62	0.57	0.00089
108	FO	150	ABOV		25	0.23	0.00036
109	URS	550	ABOV		103	0.95	0.00148
110	FO	150	ABOV		121	1.11	0.00174
111	URS	450	ABOV		224	2.06	0.00321
112	UIS	150	ABOV		82	0.75	0.00118
113	FO	650	ABOV		302	2.77	0.00433
114	FO	950	ABOV		691	6.35	0.00991
115	URS	750	ABOV		62	0.57	0.00089
116	R	50	BELO		35	0.32	0.00050
117	UIS	150	ABOV		1425	13.09	0.02045
118	URS	150	BELO		421	3.87	0.00604
119	R	650	ABOV		553	5.08	0.00793
120	FO	50	BELO		153	1.40	0.00220
121	FO	150	ABOV		377	3.46	0.00541
122	R	550	ABOV		124	1.14	0.00178
123	FO	650	ABOV		1539	14.13	0.02208
124	URS	50	BELO		29	0.27	0.00042
125	UCC	150	ABOV		776	7.13	0.01113
126	URS	450	ABOV		54	0.50	0.00077
127	FO	750	ABOV		362	3.32	0.00519
128	FO	650	ABOV		517	4.75	0.00742
129	URS	150	ABOV		64	0.59	0.00092

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (4 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
130	FO	150	BELO		14	0.13	0.00020
131	URS	50	BELO		132	1.21	0.00189
132	UCC	150	ABOV		1732	15.90	0.02485
133	URS	450	ABOV		121	1.11	0.00174
134	FO	150	BELO		9	0.08	0.00013
135	R	750	ABOV		5107	46.90	0.07328
136	FO	450	ABOV		302	2.77	0.00433
137	URS	50	BELO		425	3.90	0.00610
138	FO	750	ABOV		91	0.84	0.00131
139	FO	450	ABOV		190	1.74	0.00273
140	URS	150	BELO		88	0.81	0.00126
141	R	650	ABOV		1247	11.45	0.01789
142	URS	150	ABOV		996	9.15	0.01429
143	FO	750	ABOV		44	0.40	0.00063
144	UDG	250	ABOV		262	2.41	0.00376
145	UDG	250	ABOV		17	0.16	0.00024
146	FO	450	ABOV		487	4.47	0.00699
147	R	550	ABOV		1063	9.76	0.01525
148	UDG	250	ABOV		329	3.02	0.00472
149	R	150	ABOV		61	0.56	0.00088
150	R	650	ABOV		59	0.54	0.00085
151	UDC	250	ABOV		27	0.25	0.00039
152	R	250	ABOV		216	1.98	0.00310
153	R	450	ABOV		1099	10.09	0.01577
154	URS	50	BELO		27	0.25	0.00039
155	R	350	ABOV		467	4.29	0.00670
156	URS	450	ABOV		48	0.44	0.00069
157	R	650	ABOV		9	0.06	0.00013
158	UCR	150	ABOV		3454	31.72	0.04956
159	FO	350	ABOV		42	0.39	0.00060
160	R	650	ABOV		109	1.00	0.00156
161	URS	250	ABOV		777	7.13	0.01115
162	R	850	ABOV		1277	11.73	0.01832
163	UIS	50	ABOV		334	3.07	0.00479
164	WS	150	BELO		45	0.41	0.00065
165	URS	50	ABOV		93	0.85	0.00133
166	UDG	150	ABOV		36	0.33	0.00052
167	UCC	150	ABOV		404	3.71	0.00580
168	AVV	150	ABOV		413	3.79	0.00593
169	FO	750	ABOV		16	0.15	0.00023
170	AVF	150	ABOV		1984	18.22	0.02847
171	URS	350	ABOV		504	4.63	0.00723
172	AVV	50	ABOV		684	6.28	0.00981

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (5 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IRIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
173	R	350	ABOV		355	3.26	0.00509
174	URS	150	BELO		144	1.32	0.00207
175	UCC	150	ABOV		659	6.05	0.00946
176	URS	150	BELO		16	0.15	0.00023
177	FO	550	ABOV		10213	93.78	0.14654
178	FO	650	ABOV		1140	10.47	0.01636
179	UCC	150	ABOV		784	7.20	0.01125
180	URS	50	BELO		251	2.30	0.00360
181	URS	150	BELO		26	0.24	0.00037
182	FO	450	ABOV		8	0.07	0.00011
183	R	850	ABOV		1866	17.13	0.02677
184	UCR	50	ABOV		4282	39.32	0.06144
185	FO	450	ABOV		5122	47.03	0.07349
186	FO	50	BELO		263	2.42	0.00377
187	URS	50	BELO		66	0.61	0.00095
188	URS	150	BELO		12	0.11	0.00017
189	FO	150	BELO		169	1.55	0.00242
190	URS	150	BELO		99	0.91	0.00142
191	URS	50	BELO		20	0.18	0.00029
192	FO	250	ABOV		4128	37.91	0.05923
193	UCW	50	ABOV		551	5.06	0.00791
194	FO	350	ABOV		3611	33.16	0.05181
195	FO	750	ABOV		281	2.58	0.00403
196	UOO	50	ABOV		1688	15.50	0.02422
197	FO	150	ABOV		3168	29.09	0.04545
198	URS	50	BELO		33	0.30	0.00047
199	FO	50	BELO		83	0.76	0.00119
200	R	50	BELO		223	2.05	0.00320
201	AVF	150	BELO		229	2.10	0.00329
202	URS	150	BELO		81	0.74	0.00116
203	URS	50	BELO		35	0.32	0.00050
204	FO	150	BELO		353	3.24	0.00506
205	FO	50	BELO		8	0.07	0.00011
206	R	150	BELO		137	1.26	0.00197
207	AVF	50	BELO		12	0.11	0.00017
208	AVF	150	ABOV		2354	21.62	0.03378
209	AVV	150	ABOV		240	2.20	0.00344
210	URS	50	BELO		13	0.12	0.00019
211	AVF	50	BELO		1946	17.87	0.02792
212	R	150	ABOV		1284	11.79	0.01842
213	AVF	50	ABOV		99	0.91	0.00142
214	BT	150	ABOV		873	8.02	0.01253
215	AVF	150	ABOV		16	0.15	0.00023

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (6 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
216	AVF	50	BELO		270	2.48	0.00387
217	R	150	BELO		50	0.46	0.00072
218	AVV	50	BELO		795	7.30	0.01141
219	WS	150	BELO		47	0.43	0.00067
220	AVV	50	ABOV		15	0.14	0.00022
221	FO	750	ABOV		1367	12.55	0.01961
222	AVF	150	BELO		581	5.34	0.00834
223	R	950	ABOV		209	1.92	0.00300
224	UCW	50	ABOV		260	2.39	0.00373
225	WS	150	BELO		6	0.06	0.00009
226	R	250	ABOV		2206	20.26	0.03165
227	AVF	150	ABOV		901	8.27	0.01293
228	AVV	150	BELO		11	0.10	0.00016
229	UOP	150	ABOV		171	1.57	0.00245
230	UCB	150	ABOV		594	5.45	0.00852
231	URS	50	ABOV		1496	13.74	0.02146
232	FO	850	ABOV		136	1.25	0.00195
233	URS	50	BELO		156	1.43	0.00224
234	R	650	ABOV		151	1.39	0.00217
235	R	750	ABOV		164	1.51	0.00235
236	FO	850	ABOV		1217	11.18	0.01746
237	AVF	50	BELO		1796	16.49	0.02577
238	FO	350	ABOV		43	0.39	0.00062
239	URS	50	BELO		2199	20.19	0.03155
240	R	850	ABOV		256	2.35	0.00367
241	UUT	50	ABOV		3572	32.80	0.05125
242	URS	150	BELO		534	4.90	0.00766
243	R	550	ABOV		101	0.93	0.00145
244	URS	150	BELO		20	0.18	0.00029
245	URS	150	BELO		437	4.01	0.00627
246	R	250	ABOV		107	0.98	0.00154
247	R	250	ABOV		139	1.28	0.00199
248	URS	50	BELO		67	0.62	0.00096
249	URS	50	ABOV		9	0.08	0.00013
250	R	350	ABOV		2125	19.52	0.03050
251	R	750	ABOV		703	6.46	0.01009
252	AVV	150	ABOV		489	4.49	0.00702
253	FO	750	ABOV		347	3.19	0.00498
254	R	850	ABOV		12	0.11	0.00017
255	FO	650	ABOV		7179	65.92	0.10300
256	URS	150	BELO		13	0.12	0.00019
257	AVV	150	BELO		29	0.27	0.00042
258	FO	950	ABOV		1656	15.21	0.02376

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (7 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
GEOREF REGION CODE	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
259	R	850	ABOV		172	1.58	0.00247
260	FO	850	ABOV		61	0.56	0.00088
261	BT	150	BELO		239	2.19	0.00343
262	AVV	150	BELO		208	1.91	0.00298
263	URS	50	ABOV		921	8.46	0.01321
264	AR	150	ABOV		887	8.15	0.01273
265	FO	750	ABOV		337	3.09	0.00484
266	FO	350	ABOV		2439	22.40	0.03499
267	AVF	50	ABOV		811	7.45	0.01164
268	AVF	150	BELO		167	1.53	0.00240
269	UCR	150	ABOV		615	5.65	0.00882
270	BT	50	BELO		449	4.12	0.00644
271	AVF	150	BELO		48	0.44	0.00069
272	FO	1050	ABOV		340	3.12	0.00488
273	AVF	50	BELO		926	8.50	0.01329
274	R	750	ABOV		980	9.00	0.01406
275	AVV	50	BELO		428	3.93	0.00614
276	FO	150	ABOV		649	5.96	0.00931
277	AVF	150	BELO		199	1.83	0.00286
278	R	450	ABOV		814	7.47	0.01168
279	URS	50	BELO		10	0.09	0.00014
280	UCW	50	ABOV		1066	9.79	0.01529
281	R	150	ABOV		2376	21.82	0.03409
282	LR	50	BELO		437	4.01	0.00627
283	AR	250	ABOV		386	3.54	0.00554
284	FO	450	ABOV		1489	13.67	0.02136
285	FO	250	ABOV		1531	14.06	0.02197
286	LR	150	ABOV		215	1.97	0.00308
287	FO	750	ABOV		85	0.78	0.00122
288	R	850	ABOV		1333	12.24	0.01913
289	R	950	ABOV		283	2.60	0.00406
290	R	250	ABOV		994	9.13	0.01426
291	R	1050	ABOV		35	0.32	0.00050
292	UUT	50	ABOV		47	0.43	0.00067
293	FO	850	ABOV		20	0.18	0.00029
294	UUT	150	ABOV		954	8.76	0.01369
295	AVF	150	ABOV		5362	49.24	0.07693
296	R	650	ABOV		30	0.28	0.00043
297	UIL	50	ABOV		1160	10.65	0.01664
298	UIL	150	ABOV		305	2.80	0.00436
299	UES	50	BELO		3832	35.19	0.05498
300	URS	50	BELO		584	5.36	0.00838
301	R	550	ABOV		34	0.31	0.00049

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (8 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES - LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	-- AREAL COVERAGE -- PIXELS	ACRES	SQ MILES
302	URS	50	BELO		757	6.95	0.01086
303	URS	50	ABOV		21	0.19	0.00030
304	FO	750	ABOV		197	1.81	0.00283
305	R	550	ABOV		19	0.17	0.00027
306	URS	50	ABOV		13	0.12	0.00019
307	LR	50	BELO		8	0.07	0.00011
308	R	550	ABOV		49	0.45	0.00070
309	URS	150	BELO		82	0.75	0.00118
310	AVF	50	ABOV		5175	47.53	0.07427
311	URS	150	ABOV		1671	15.34	0.02398
312	R	350	ABOV		979	8.99	0.01405
313	FO	850	ABOV		42	0.39	0.00060
314	UES	150	BELO		46	0.42	0.00066
315	UES	150	ABOV		903	8.29	0.01296
316	URS	50	ABOV		2087	19.16	0.02994
317	AVF	150	BELO		108	0.99	0.00155
318	ACC	50	ABOV		1222	11.22	0.01753
319	UES	50	ABOV		707	6.49	0.01014
320	UES	150	BELO		12	0.11	0.00017
321	URS	150	ABOV		64	0.59	0.00092
322	R	950	ABOV		137	1.26	0.00197
323	UES	50	ABOV		18	0.17	0.00026
324	URS	150	ABOV		11	0.10	0.00016
325	R	450	ABOV		1052	9.66	0.01509
326	URS	50	ABOV		2081	19.11	0.02986
327	URS	150	BELO		24	0.22	0.00034
328	FO	750	ABOV		1811	16.63	0.02598
329	UUT	50	ABOV		65	0.60	0.00093
330	FO	850	ABOV		1324	12.16	0.01900
331	URS	150	ABOV		61	0.56	0.00088
332	UES	150	BELO		11	0.10	0.00016
333	URS	150	BELO		33	0.35	0.00055
334	UES	150	BELO		71	0.65	0.00102
335	UES	150	BELO		13	0.12	0.00019
336	AVF	50	ABOV	UIS	1913	17.61	0.02752
337	R	550	ABOV		15	0.14	0.00022
338	FO	550	ABOV		9	0.08	0.00013
339	R	550	ABOV		46	0.42	0.00066
340	ACP	650	ABOV		6963	63.94	0.09990
341	R	650	ABOV		17	0.16	0.00024
342	UES	150	BELO		21	0.19	0.00030
343	URS	150	ABOV		26	0.24	0.00037
344	URS	50	BELO		155	1.42	0.00222

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240.000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
345	R	550	ABOV		47	0.43	0.00067
346	ACP	550	ABOV		5403	49.61	0.07752
347	FO	650	ABOV		28	0.26	0.00040
348	FO	750	ABOV		1067	9.80	0.01531
349	UES	150	BELO		21	0.19	0.00030
350	ACP	450	ABOV		3915	35.95	0.05617
351	R	950	ABOV		2574	23.64	0.03693
352	UES	150	BELO		169	1.55	0.00242
353	UES	50	ABOV		191	1.75	0.00274
354	ACP	750	ABOV		3196	29.35	0.04586
355	URS	150	ABOV		43	0.44	0.00069
356	ACP	350	ABOV		3737	34.32	0.05362
357	AVF	50	ABOV		19796	181.78	0.28403
358	URS	150	BELO		35	0.32	0.00050
359	UOP	150	BELO		223	2.09	0.00327
360	UOP	50	BELO		869	7.98	0.01247
361	ACP	250	ABOV		1971	18.10	0.02828
362	URS	50	BELO		46	0.42	0.00066
363	UOC	50	ABOV		864	7.93	0.01240
364	UCR	50	ABOV		621	5.70	0.00891
365	UIS	50	ABOV		502	4.61	0.00720
366	UES	50	BELO		11	0.10	0.00016
367	ACP	150	ABOV		6924	63.58	0.09935
368	AVF	150	ABOV		166	1.52	0.00238
369	AVV	50	ABOV		1460	13.41	0.02095
370	UIS	50	BELO		686	6.30	0.00984
371	AVV	50	ABOV	UIS	526	4.83	0.00755
372	URH	50	ABOV		700	6.43	0.01004
373	URH	50	BELO		121	1.11	0.00174
374	UOP	150	BELO		27	0.25	0.00039
375	UIS	50	ABOV		35	0.32	0.00050
376	AVV	50	ABOV		703	6.46	0.01009
377	R	650	ABOV		496	4.55	0.00712
378	UIS	150	BELO		26	0.24	0.00037
379	UIS	50	ABOV	UIS	1006	9.24	0.01443
380	R	750	ABOV		4513	41.44	0.06475
381	R	850	ABOV		57	0.52	0.00082
382	BES	50	BELO		781	7.17	0.01121
383	R	850	ABOV		2184	20.06	0.03134
384	ACC	50	ABOV	UIS	940	8.63	0.01349
385	AVF	50	ABOV		14330	131.59	0.20561
386	FO	950	ABOV		20	0.18	0.00029
387	URS	50	ABOV		1923	17.66	0.02759

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (10 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
388	URS	50	BELO		505	4.64	0.00725
389	BES	150	BELO		194	1.78	0.00278
390	UIS	150	BELO		37	0.34	0.00053
391	AVV	50	ABOV		704	6.46	0.01010
392	FO	950	ABOV		99	0.91	0.00142
393	AVV	150	ABOV		665	6.11	0.00954
394	AVV	50	ABOV		1390	12.76	0.01994
395	URS	50	BELO		297	2.73	0.00426
396	URS	50	ABOV		49	0.45	0.00070
397	R	650	ABOV		6414	58.90	0.09203
398	URS	150	BELO		27	0.25	0.00039
399	UIW	250	ABOV		126	1.16	0.00181
400	UIW	150	ABOV		222	2.04	0.00319
401	VV	50	BELO		658	6.04	0.00944
402	VV	150	BELO		21	0.19	0.00030
403	AVV	250	ABOV		1186	10.89	0.01702
404	LR	50	BELO		333	3.06	0.00478
405	AVF	50	BELO		1228	11.28	0.01762
406	AVV	150	ABOV		583	5.35	0.00836
407	AVV	350	ABOV		301	2.76	0.00432
408	ACC	50	ABOV		197	1.81	0.00283
409	UUT	50	BELO		201	1.85	0.00288
410	ACC	50	ABOV	ACC	1188	10.91	0.01705
411	AVV	50	ABOV	ACC	4309	39.57	0.06183
412	ACP	50	ABOV		3794	34.84	0.05444
413	ACP	250	ABOV		301	2.76	0.00432
414	AVF	50	BELO		211	1.94	0.00303
415	ACP	250	ABOV		184	1.69	0.00264
416	R	750	ABOV		9	0.08	0.00013
417	ACP	550	ABOV		31	0.28	0.00044
418	R	550	ABOV		8639	79.33	0.12395
419	UIL	50	ABOV		1112	10.21	0.01595
420	ACC	50	ABOV		2144	19.69	0.03076
421	WS	50	ABOV		55	0.51	0.00079
422	WS	50	ABOV	ACC	13	0.12	0.00019
423	WS	50	BELO	ACC	38	0.35	0.00055
424	LF	50	BELO		261	2.40	0.00374
425	AVV	250	ABOV		9	0.08	0.00013
426	R	650	ABOV		954	8.76	0.01369
427	AVF	50	ABOV		5099	46.82	0.07316
428	R	450	ABOV		6205	56.99	0.08904
429	WS	50	BELO		284	2.61	0.00407
430	R	150	ABOV		7439	68.31	0.10673

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (11 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
431	R	250	ABOV		7887	72.42	0.11316
432	F	350	ABOV		6004	55.13	0.08615
433	AVF	50	ABOV	ACC	22	0.20	0.00032
434	URS	50	BELO		74	0.68	0.00106
435	F	250	ABOV		193	1.77	0.00277
436	UUT	50	BELO		1290	11.85	0.01851
437	R	150	ABOV		58	0.53	0.00083
438	AVF	50	BELO		232	2.13	0.00333
439	UCO	50	ABOV		89	0.82	0.00128
440	UCO	50	BELO		486	4.46	0.00697
441	URS	50	ABOV		1394	12.80	0.02000
442	LR	50	BELO		3899	35.80	0.05594
443	ACP	250	ABOV		672	6.17	0.00964
444	ACC	50	ABOV		3687	33.86	0.05290
445	AR	650	ABOV		840	7.71	0.01205
446	AVF	50	BELO		3526	32.38	0.05059
447	LR	50	ABOV		917	8.42	0.01316
448	ACC	50	ABOV		2190	20.11	0.03142
449	UUT	50	ABOV		674	6.19	0.00967
450	AVV	50	BELO	ACC	25	0.23	0.00036
451	AVF	50	ABOV	AVV	1810	16.62	0.02597
452	R	650	ABOV		197	1.81	0.00283
453	LR	50	BELO		15	0.14	0.00022
454	WS	50	BELO	ACC	11	0.10	0.00016
455	AVF	50	BELO		83	0.76	0.00119
456	WS	50	BELO		416	3.82	0.00597
457	AVF	50	BELO	AVV	88	0.81	0.00126
458	LR	50	BELO		72	0.66	0.00103
459	AVV	50	ABOV	AVV	1931	17.73	0.02771
460	AVF	50	ABOV		415	3.81	0.00595
461	R	450	ABOV		2559	23.50	0.03672
462	AVF	50	ABOV		4229	38.83	0.06068
463	UUT	150	ABOV		3009	27.63	0.04317
464	AVF	150	ABOV		1765	16.22	0.02534
465	R	250	ABOV		517	4.75	0.00742
466	AVF	50	BELO		51	0.47	0.00073
467	ACP	50	ABOV	AVV	1001	9.19	0.01436
468	AVF	50	ABOV	AVV	955	8.77	0.01370
469	AVF	50	BELO		273	2.51	0.00392
470	R	550	ABOV		169	1.55	0.00242
471	ACC	150	ABOV		1689	15.51	0.02423
472	AVF	50	BELO	AVV	9	0.08	0.00013
473	AVF	50	BELO	AVV	164	1.51	0.00235

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (12 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IRIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
474	AVF	50	ABOV		43	0.39	0.00062
475	AVV	50	BELO		576	5.29	0.00826
476	AVV	50	BELO	AVV	117	1.07	0.00168
477	AVV	50	ABOV		350	3.21	0.00502
478	LR	50	BELO		31	0.28	0.00044
479	AVF	50	ABOV		9	0.08	0.00013
480	AVF	50	BELO		9	0.08	0.00013
481	ACP	50	BELO	AVV	28	0.26	0.00040
482	LR	50	ABOV		88	0.81	0.00126
483	AVF	50	BELO		9	0.08	0.00013
484	AVV	150	ABOV		7365	67.64	0.10569
485	AVV	50	ABOV		8384	76.99	0.12029
486	AVF	50	ABOV		1820	16.71	0.02611
487	LR	150	ABOV		59	0.54	0.00085
488	AVF	50	BELO		2201	20.21	0.03158
489	URS	50	BELO		790	7.25	0.01133
490	ACP	50	BELO	AVV	97	0.89	0.00139
491	ACP	250	ABOV		24711	226.91	0.35455
492	URS	50	ABOV		410	3.76	0.00588
493	AVV	150	ABOV		1282	11.77	0.01839
494	AVF	150	ABOV	URS	4059	37.27	0.05824
495	AVV	150	ABOV	URS	503	4.62	0.00722
496	AVV	250	ABOV	URS	451	4.14	0.00647
497	ACP	250	ABOV	URS	1683	15.45	0.02415
498	ACP	350	ABOV		9204	84.52	0.13206
499	ACP	450	ABOV		2958	27.16	0.04244
500	ACP	550	ABOV		83	0.76	0.00119
501	AVV	150	ABOV		3576	32.84	0.05131
502	UIW	150	ABOV		829	7.61	0.01189
503	AVF	150	ABOV		1965	18.04	0.02819
504	AVV	150	ABOV		10647	97.77	0.15276
505	ACC	150	ABOV		1347	12.37	0.01933
506	LR	50	BELO		15	0.14	0.00022
507	AVV	50	BELO		3673	33.73	0.05270
508	AVV	50	ABOV		206	1.89	0.00296
509	AVF	50	BELO		10	0.09	0.00014
510	AVF	250	ABOV	URS	36	0.33	0.00052
511	R	350	ABOV		1721	15.80	0.02469
512	WWP	450	ABOV		25	0.23	0.00036
513	AVV	50	ABOV		5058	46.45	0.07257
514	AVF	50	BELO		235	2.16	0.00337
515	AVV	250	ABOV		462	4.24	0.00663
516	AVF	250	ABOV	URS	213	1.96	0.00306

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (13 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
517	ACP	150	ABOV	URS	29	0.27	0.00042
518	AVV	150	ABOV	URS	848	7.79	0.01217
519	AVV	250	ABOV	URS	79	0.73	0.00113
520	WS	50	BELO		830	7.62	0.01191
521	AVF	150	ABOV		180	1.65	0.00258
522	AVV	50	BELO		231	2.12	0.00331
523	AVV	50	ABOV		28	0.26	0.00040
524	R	450	ABOV		253	2.32	0.00363
525	BT	450	ABOV		140	1.29	0.00201
526	AVF	50	BELO		1824	16.75	0.02617
527	BT	350	ABOV		756	6.94	0.01085
528	LR	50	BELO		487	4.47	0.00699
529	ACC	50	ABOV		134	1.23	0.00192
530	ACC	150	ABOV		84	0.77	0.00121
531	AVV	150	ABOV	URS	2100	19.28	0.03013
532	ACP	550	ABOV		28	0.26	0.00040
533	R	350	ABOV		761	6.99	0.01092
534	AVF	50	ABOV		3366	30.91	0.04830
535	AVV	250	ABOV	URS	1155	10.61	0.01657
536	AVV	50	BELO		390	3.58	0.00560
537	URS	150	ABOV		708	6.50	0.01016
538	ACP	150	ABOV	URS	1777	16.32	0.02550
539	ACP	150	ABOV	URS	21	0.19	0.00030
540	ACP	250	ABOV	URS	1321	12.13	0.01895
541	AVV	250	ABOV	URS	133	1.22	0.00191
542	AVV	50	BELO		578	5.31	0.00829
543	URS	150	ABOV	URS	1687	15.49	0.02421
544	R	450	ABOV		13	0.12	0.00019
545	BT	250	ABOV		6238	57.28	0.08950
546	AVV	50	ABOV		237	2.18	0.00340
547	R	250	ABOV		49	0.45	0.00070
548	AVF	50	BELO		4574	42.00	0.06563
549	BT	350	ABOV		50	0.46	0.00072
550	BBR	50	BELO		183	1.68	0.00263
551	AVV	50	ABOV		500	4.59	0.00717
552	WWP	250	ABOV		270	2.48	0.00387
553	ACP	450	ABOV		428	3.93	0.00614
554	R	250	ABOV		105	0.96	0.00151
555	AVF	50	ABOV		1397	12.83	0.02004
556	AVV	150	ABOV	URS	51	0.47	0.00073
557	AVV	50	BELO		918	8.43	0.01317
558	ACP	250	ABOV		36	0.33	0.00052
559	AVV	150	ABOV		63	0.58	0.00090

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (14 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240.000   1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES - LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	-- AREAL COVERAGE -- PIXELS	ACRES	SQ MILES
560	AVV	50	BELO		11	0.10	0.00016
561	UES	50	BELO		4089	37.55	0.05867
562	ACP	250	ABOV	URS	324	2.98	0.00465
563	UES	50	ABOV		102	0.94	0.00146
564	R	250	ABOV		879	8.07	0.01261
565	R	350	ABOV		1593	14.63	0.02286
566	AVF	50	ABOV		273	2.51	0.00392
567	BT	350	ABOV		29	0.27	0.00042
568	AVV	150	ABOV		185	1.70	0.00265
569	ACP	150	ABOV		37193	341.58	0.53372
570	AVV	50	BELO		47323	434.55	0.67899
571	R	450	ABOV		568	5.22	0.00815
572	AVV	50	ABOV		52	0.48	0.00075
573	AVF	50	ABOV		291	2.67	0.00418
574	ACP	150	ABOV		2124	19.50	0.03048
575	ACC	50	ABOV		720	6.61	0.01033
576	ACC	150	ABOV		91	0.84	0.00131
577	ACC	50	ABOV		100	0.92	0.00143
578	ACC	50	BELO		6112	56.12	0.08769
579	AVF	150	ABOV		40	0.37	0.00057
580	URS	50	ABOV		337	3.09	0.00484
581	AVV	50	ABOV		8387	77.02	0.12034
582	AR	150	ABOV		425	3.90	0.00610
583	BBR	50	BELO		473	4.34	0.00679
584	URH	150	ABOV		283	2.60	0.00406
585	AVV	150	ABOV		49	0.45	0.00070
586	AVV	50	ABOV		12078	110.91	0.17329
587	UUS	50	BELO		1537	14.11	0.02205
588	AVF	50	BELO		400	3.67	0.00574
589	AVF	50	ABOV		878	8.06	0.01260
590	AVF	50	BELO		52	0.48	0.00075
591	AR	50	ABOV		381	3.50	0.00547
592	ACP	350	ABOV		33	0.30	0.00047
593	URS	150	ABOV		402	3.69	0.00577
594	R	550	ABOV		12	0.11	0.00017
595	UIS	150	ABOV		464	4.26	0.00666
596	ACC	50	ABOV		248	2.28	0.00356
597	UIS	50	ABOV		1148	10.54	0.01647
598	WO	50	BELO		3269	30.02	0.04690
599	AVF	50	BELO		459	4.21	0.00659
600	AVV	50	ABOV		202	1.85	0.00290
601	AVV	50	BELO		11713	107.56	0.16806
602	URS	50	ABOV		353	3.29	0.00514

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (15 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240.000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY. ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
GEOREF REGION CODE	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
603	ACP	50	ABOV		63	0.58	0.00090
604	ACC	150	ABOV		3178	29.18	0.04560
605	R	250	ABOV		33	0.30	0.00047
606	R	250	ABOV		16	0.15	0.00023
607	UIS	50	ABOV		13	0.12	0.00019
608	AVV	150	ABOV		15	0.14	0.00022
609	R	250	ABOV		37	0.34	0.00053
610	AR	50	ABOV		2164	19.87	0.03105
611	AR	150	ABOV		139	1.28	0.00199
612	ACC	50	ABOV		149	1.37	0.00214
613	AVV	50	BELO		108	0.99	0.00155
614	URS	150	ABOV		400	3.67	0.00574
615	BT	350	ABOV		94	0.86	0.00135
616	AVF	50	ABOV		276	2.53	0.00396
617	AVF	50	BELO		3931	36.10	0.05640
618	ACC	50	ABOV		14	0.13	0.00020
619	AR	150	ABOV		378	3.47	0.00542
620	ACP	50	ABOV		2050	18.82	0.02941
621	ACP	150	ABOV		82	0.75	0.00118
622	AVV	150	ABOV		1804	16.57	0.02588
623	ACP	50	ABOV		555	5.10	0.00796
624	AVV	150	ABOV		286	2.63	0.00410
625	ACP	250	ABOV		5192	47.68	0.07449
626	ACP	150	ABOV		3306	30.36	0.04743
627	URS	150	ABOV		6862	63.01	0.09846
628	URS	150	ABOV		471	4.33	0.00676
629	URS	150	ABOV		1141	10.48	0.01637
630	AVV	50	ABOV		49	0.45	0.00070
631	URS	50	ABOV		267	2.45	0.00383
632	ACP	250	ABOV		340	3.12	0.00488
633	URS	50	ABOV		222	2.04	0.00319
634	UUT	250	ABOV		55	0.51	0.00079
635	AVV	150	ABOV		114	1.05	0.00164
636	AVV	250	ABOV		576	5.29	0.00826
637	URS	250	ABOV		23	0.21	0.00033
638	ACP	250	ABOV		24	0.22	0.00034
639	AVF	150	ABOV		44	0.40	0.00063
640	AVF	50	ABOV		480	4.41	0.00689
641	UUT	150	ABOV		2492	22.88	0.03576
642	AVF	250	ABOV		210	1.93	0.00301
643	ACP	50	BELO		750	6.89	0.01076
644	ACP	250	ABOV		124	1.14	0.00178
645	WWP	250	ABOV		172	1.58	0.00247

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (16 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
646	URS	250	ABOV		12	0.11	0.00017
647	ACP	50	ABOV		102	0.94	0.00146
648	AVV	150	ABOV		45	0.41	0.00065
649	URS	250	ABOV		15	0.14	0.00022
650	URS	50	ABOV		101	0.93	0.00145
651	URS	250	ABOV		35	0.32	0.00050
652	FO	50	ABOV		135	1.24	0.00194
653	URS	150	ABOV		175	1.61	0.00251
654	ACP	250	ABOV		2251	20.67	0.03230
655	AVF	250	ABOV		243	2.23	0.00349
656	BT	150	ABOV		12	0.11	0.00017
657	AVV	150	ABOV		71	0.65	0.00102
658	WWP	250	ABOV		73	0.67	0.00105
659	R	250	ABOV		164	1.51	0.00235
660	UUS	50	ABOV		67	0.62	0.00096
661	WWP	150	ABOV		304	2.79	0.00436
662	UUS	50	BELO		24	0.22	0.00034
663	ACC	50	BELO		232	2.13	0.00333
664	ACP	150	ABOV		11	0.10	0.00016
665	ACC	50	ABOV		447	4.10	0.00641
666	ACC	150	ABOV		1733	15.91	0.02487
667	WWP	150	ABOV		321	2.95	0.00461
668	ACP	150	ABOV		91	0.84	0.00131
669	ACP	250	ABOV		52	0.48	0.00075
670	AVF	50	BELO		4593	42.18	0.06590
671	UCC	50	ABOV		962	8.83	0.01380
672	ACC	150	ABOV		144	1.32	0.00207
673	ACC	50	BELO		86	0.79	0.00123
674	R	250	ABOV		54	0.50	0.00077
675	ACP	150	ABOV		13	0.12	0.00019
676	ACC	150	ABOV		2953	27.12	0.04237
677	URS	50	ABOV		613	5.63	0.00880
678	AVF	50	ABOV		627	5.76	0.00900
679	URS	50	ABOV		15	0.15	0.00023
680	BT	250	ABOV		771	7.08	0.01106
681	ACP	50	ABOV		177	1.63	0.00254
682	AVF	50	ABOV		16	0.15	0.00023
683	AVF	150	ABOV		2895	26.58	0.04154
684	BT	150	ABOV		2284	20.97	0.03277
685	URS	150	ABOV		49	0.45	0.00070
686	AVF	50	ABOV		9	0.08	0.00013
687	AVV	50	BELO		942	8.65	0.01352
688	AVV	50	ABOV		2857	26.23	0.04099

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (17 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240.000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY. ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	PIXELS	ACRES	SQ MILES
	- DATA PLANE ATTRIBUTES -				-- AREAL COVERAGE --		
689	ACP	150	ABOV		1228	11.28	0.01762
690	URS	150	ABOV		103	0.95	0.00148
691	AVV	150	ABOV		399	3.66	0.00572
692	AVV	50	ABOV		652	5.99	0.00935
693	UCC	150	ABOV		65	0.60	0.00093
694	URS	50	ABOV		183	1.68	0.00263
695	URS	150	ABOV		29	0.27	0.00042
696	AVF	50	BELO		1371	12.59	0.01967
697	AVV	150	ABOV		80	0.73	0.00115
698	AVV	50	ABOV		1579	14.50	0.02266
699	ACC	150	ABOV		1308	12.01	0.01877
700	AVV	150	ABOV		419	3.85	0.00601
701	URS	150	ABOV		82	0.75	0.00118
702	AVV	150	ABOV		2456	22.55	0.03524
703	BBR	50	BELO		2295	21.07	0.03293
704	AVV	150	ABOV		1967	18.06	0.02822
705	AVF	50	ABOV		1710	15.70	0.02454
706	ACP	150	ABOV		2974	27.31	0.04267
707	AVF	150	ABOV		855	7.85	0.01227
708	AVV	150	ABOV		1721	15.80	0.02469
709	ACP	150	ABOV		6018	55.26	0.08635
710	URS	50	ABOV		448	4.11	0.00643
711	AVF	150	ABOV		6268	57.56	0.08993
712	ACC	50	BELO		2849	26.16	0.04088
713	URS	150	ABOV		1147	10.53	0.01646
714	AVV	50	ABOV		241	2.21	0.00346
715	ACC	50	ABOV		1344	12.34	0.01928
716	URS	50	BELO		249	2.29	0.00357
717	ACC	150	ABOV		1357	12.46	0.01947
718	URS	50	ABOV		317	2.91	0.00455
719	URS	50	ABOV		371	3.41	0.00532
720	URS	150	ABOV		2869	26.35	0.04116
721	AVV	150	ABOV		15	0.14	0.00022
722	URS	150	ABOV		588	5.40	0.00844
723	AVV	150	ABOV		1468	13.48	0.02106
724	AVF	150	ABOV		618	5.67	0.00887
725	AVV	150	ABOV		39	0.36	0.00056
726	AVV	250	ABOV		1544	14.18	0.02215
727	AVV	250	ABOV		38	0.35	0.00055
728	ACP	150	ABOV		8199	75.29	0.11764
729	URS	150	ABOV		5207	47.81	0.07471
730	ACP	150	ABOV		3363	30.88	0.04825
731	AVV	150	ABOV		509	4.67	0.00730

Table B-8. Healdsburg Quadrangle Summary of Georeference Base (18 of 18)

HEALDSBURG QUADRANGLE: NW QUARTER SECTION
EFFECTIVE PIXEL SCALE: 1:240,000 1 PIXEL = 400 SQ FT

IBIS TEST DATA BASE FOR
US ARMY, ENGINEER TOPOGRAPHIC LABORATORIES

SUMMARY OF GEOREFERENCE BASE

GEOREF REGION CODE	- DATA PLANE ATTRIBUTES - LAND USE	MEAN ELEV	FLOOD PLAIN	L USE CHANGE	-- AREAL COVERAGE -- PIXELS	ACRES	SQ MILES
732	AVV	50	ABOV		324	2.98	0.00465
733	LP	50	BELO		827	7.59	0.01167
734	AVV	150	ABOV		676	6.21	0.00970
735	AVV	50	BELO		1626	14.93	0.02333
736	AVV	50	ABOV		1637	15.03	0.02349
737	AVV	50	ABOV		684	6.28	0.00981
738	AVV	150	ABOV		3163	29.04	0.04538
739	AVV	150	ABOV		230	2.11	0.00330
740	ACP	150	ABOV		1955	17.95	0.02805
741	ACP	250	ABOV		455	4.18	0.00653
742	UIS	150	ABOV		472	4.33	0.00677
743	ACP	50	ABOV		797	7.32	0.01144
744	ACP	250	ABOV		317	2.91	0.00455
745	ACC	150	ABOV		1143	10.50	0.01640
746	BEQ	50	BELO		1441	13.23	0.02068
747	AR	50	ABOV		991	9.10	0.01422
748	WD	50	BELO		798	7.33	0.01145
749	ACP	150	ABOV		782	7.18	0.01122
750	BT	150	ABOV		671	6.16	0.00963
751	AVV	150	ABOV		888	8.15	0.01274
752	AVF	150	ABOV		2603	23.90	0.03735
753	AVF	50	BELO		3802	34.91	0.05455
754	AVV	150	ABOV		2025	18.59	0.02905
755	WWP	150	ABOV		54	0.50	0.00077
756	AVF	50	ABOV		377	3.46	0.00541
757	AR	150	ABOV		265	2.43	0.00380
758	AVV	150	ABOV		454	4.17	0.00651
759	URS	150	ABOV		1501	13.78	0.02154
760	AVV	150	ABOV		278	2.55	0.00399
761	URS	150	ABOV		256	2.35	0.00367
762	AVV	50	BELO		869	7.98	0.01247
763	AVV	150	ABOV		359	3.30	0.00515
764	AVV	50	ABOV		82	0.75	0.00118
					1008000	9255.39	14.46238